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COLD WATER SUPPLY STORAGE AND MAINS DISTRIBUTION

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Cold Water Supply Storage and Mains Distribution

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Health Technical Memorandum Cold Water Supply Storage and Mains Distribution

Introduction

This Technical Memorandum is intended as a guide for engineers, architects, service engineers, surveyors, contractors and for others interested in the design and installation of cold water supply pipework and distribution systems in hospital and health building complexes, from the source of supply to the local cisterns (excluding waste water preventers for WCs), but not including the outgoing services except where necessary for clarification. Guidance on the cold water distribution system within individual departments is given in relevant Health Building Notes.

Whilst some guidance on the water services mentioned below is given in this memorandum it is not intended to cover them fully:

Laundries—see Building Note No 25
Boiler House—See Building Note No 16
Sterile Supply Departments—See Building Note No 13
Hydro-therapy pools
Complete fire installations
Purified water systems
Cooling water systems

1 General

1.1 Scope

The Memorandum outlines the principles involved in the installation of the cold water supply and distribution system for health buildings. Basically they apply to all health buildings, but some deviation may become necessary where the differing requirements for the various water authorities must be met. Distribution design in health buildings may vary, as for instance in System Building hospital manuals for cold water services systems, but the principles laid down in this memorandum should be observed in the design.

1.2 Definitions

For the purpose of this memorandum the following definitions apply:

Water authorities

1.2.1 The water authorities in England and Wales were established under the Water Act 1973 as autonomous bodies. Their responsibilities cover the management of all water services and include water conservation, water supplies, sewerage and sewage disposal, control of river pollution, maintenance, improvement and development of fisheries, land drainage and flood prevention and water recreation. There are 9 Regional Water Authorities in England and the Welsh National Water Development Authority in Wales; a map showing their boundaries is included as Appendix 6. The 1973 re-organisation left water companies in being, but as agents of the water authorities; similarly, sewerage (but not sewage treatment and disposal except in Greater London) is managed for the water authorities under agreement by most district councils and London boroughs. The Greater London Authorities still have responsibility for land drainage and flood prevention in their area.

In Scotland, under the Local Government (Scotland) Act 1973, water supply, sewerage and sewage disposal is the function of the 9 regional councils and 3 island councils and the Central Scotland Water Development Board. Pollution control is exercised by 7 river purification boards covering the whole mainland, while the 3 island councils are responsible in their areas.

Statutory water undertaker

1.2.2 An Authority given the duty by Parliamentary Statute (Water Act 1973) to undertake the provision of a potable water supply within a prescribed area. The functions of statutory water undertakers (which will include Water Companies, Joint Water Boards, and Joint Water Committees) are exercisable by the Water Authorities in England and Wales, but are independent in Scotland.

Independent water supply

1.2.3 A supply of water taken from a source, other than from the mains of a statutory water undertaker; either direct or in conjunction with a private supplier. Sources may be wells, boreholes, springs, adits, streams, rivers, canals, lakes or rain water catchment.

Water potability

1.2.4 The suitability of the physical, bacteriological and chemical state of water for human consumption and drinking and culinary purposes.

Bacteriological analysis

1.2.5 Assessment of the pathogenic bacteria present and active in the water.

Chemical analysis

1.2.6 Assessment of the minerals and salts in solution in the water.

Physical characteristics

1.2.7 Assessment of the solids in suspension, smell, taste and electrical conductivity of water.

Hardness

1.2.8 Materials in water which react with soap causing precipitation, which appears as a scum on the surface. No lather can be formed until enough soap has been dissolved to react with these materials. The portion of the total hardness deposited when the water is boiled is called "temporary hardness" and is mainly calcium and magnesium bicarbonate. The remaining hardness is called "permanent hardness" or more exactly non-carbonate hardness. Hardness is normally measured as the equivalent amount of calcium carbonate in milligrammes per litre.

Water treatment

1.2.9 Process of effecting changes in the physical, chemical and/or bacteriological state of water to render it suitable for the purpose to which it is to be applied.

Sterilization

1.2.10 The process of removing harmful bacteria to render the water fit for human consumption. This does not refer to the levels of sterilization required in hospitals for clinical or pharmaceutical purposes, but normal sterilization by chlorine or ozone which is sufficient for domestic consumption.

Backsiphonage

1.2.11 All types of backflow whereby water intended for drinking and domestic use may become contaminated, either by contact or by mixing, with water which could contain matter potentially hazardous to health or which could give rise to complaint from consumers.

Re-cycling

1.2.12 The process of recovering waste water for re-use.

Cistern

1.2.13 A container for local water storage having a free water surface at atmospheric pressure and normally fitted with a ball valve on the inlet connection.

Capacity of cistern

1.2.14 The capacity of the cistern measured up to the water line.

Water line

1.2.15 A line marked inside a cistern to indicate the highest water level at which the ball valve should be adjusted to shut off.

Cylinder

1.2.16 A closed cylindrical vessel with parallel sides and domed ends for circulation or storage of hot water, under more than atmospheric pressure.

Tank

1.2.17 A closed rectangular vessel used for the circulation or storage of hot water under more than atmospheric pressure. Small storage reservoirs, particularly of the elevated type are frequently constructed of standard steel or cast iron sections bolted together. These are commonly called "tanks", although they are cisterns by definition.

Total stored water

1.2.18 The summation of hot water and stored cold water plus fire fighting water if stored, when considering common storage.

Service pipe from statutory water undertaker's mains

1.2.19 Piping, metering, and control valves connecting the statutory water undertaker's mains to supply point within the site. This is usually located at the site boundary.

Distribution mains

1.2.20 Pipes for the conveyance of water from the service pipe connection to storage cisterns or reservoirs and or branch pipes at statutory water undertaker's mains pressure within the site, and for the conveyance of water from storage cisterns or reservoirs to stop valves controlling supply at entry into buildings within the hospital complex.

Branch pipes

1.2.21 Pipes connected between distribution mains at statutory water undertaker's mains pressure to stop valves controlling supply at entry into buildings within the hospital complex and for conveyance of water for drinking and culinary purposes, and for fire fighting purposes through wet and dry risers, small bore hose reels, and sprinkler systems.

Well

1.2.22 Any shaft or excavation made for the purpose of intercepting ground water, exceeding 1 metre in diameter if hand excavated, or exceeding 1·8 metre diameter irrespective of the method of construction.

Borehole

1.2.23 A shaft 1·8 metre or less in diameter and constructed by boring.

Ward unit

1.2.24 A group of rooms which make up the working area for patient care, ie patients' bedrooms, day spaces, treatment, utility and test rooms, bathrooms, showers and WCs, pantry, staff rooms, cleaners' rooms, etc and the associated circulation spaces.

It should be noted that while all current Health Building guidance literature uses the term "Ward Unit", in new type hospitals such as Nucleus the term "Nursing Section" has been used.

1.3 Compliance with British Standards

All materials used in the construction of works referred to in this memorandum must be in accordance with relevant British Standards and Codes of Practice available. A list of some of the available relevant publications by the British Standard Institution is given in Appendix 7.

2 Source of supply

2.1 General

2.1.1 Normally the source of water supply to a health building is a service pipe connection to the mains of the statutory water undertaker for the area. If the quantity and rate of flow is inadequate or if the cost of providing the service connection appears to be uneconomical, alternative sources of supply should be investigated. The feasibility of such an independent supply should be decided by comparing, on a present worth basis, the capital

costs (of the construction of works, including mains, pumping plant, treatment plant etc) and revenue costs (of electricity for pumping, water treatment chemicals, direct and indirect maintenance and associated management costs, regular water analysis tests etc) with the long term cost of a water supply from the statutory water undertaker. Where the constraint is only that of inadequacy of the statutory water undertaker's supply, the health building needs should be met by using both sources; drinking, culinary and special hygienic services having priority of choice, which would be that of statutory water undertaker's supply. Such a choice could, by limiting its use to services not requiring the highest level of hygiene, result in a reduction of the need for treatment of the independent supply.

2.1.2 Provision should be included for alternative arrangements to meet an emergency, regardless of the source or sources of supply finally adopted. Any provision to cover emergencies should be on the basis of a reasoned assessment of the probabilities of loss of the selected source and the possible duration of such a loss in relation to the storage capacity on the site and the ease with which temporary facilities could be set up, bearing in mind the hazards that interruption of supply could cause. Alternative arrangements would include the provision of a second service connection from the statutory water undertaker or another independent supply. In either case these alternative supplies should not be likely to be affected by the same cause as that of the loss of the original supply. Physical inter-connection of pipework and valves of a statutory water undertaker's supply with any independent supply is normally prohibited by Model Water Byelaws. The statutory water undertaker should be advised of the NHS need to use any independent supply as well as the statutory water undertaker's supply and advice should be sought on the limitations imposed in respect of break cisterns and interconnection thereafter.

2.2 Supplies from a Statutory Water Undertaker

2.2.1 As in the case of other utility services the requisitioning of a supply of water from a statutory water undertaker must be considered as part of the investigation of any site for suitability for health building purposes.

The preliminary application to the statutory water undertaker should include:

a. A statement of the purposes for which the supply is required.

b. An estimate of daily quantity, minimum and maximum rates of flow, and times of peak demand.

c. The proposed method of storage and probable number and purpose of direct connections to pressure mains.

2.2.2 The statutory water undertaker should be asked to advise on:

a. The nearest point of service connection.

b. The minimum and maximum pressures available at service connection.

c. Details of the physical, chemical and bacteriological characteristics of the water supply and scope of any possible variations in such characteristics.

d. Possibility of an alternative service connection from some other part of the statutory water undertaker's network, including pressure details.

This feasibility study should normally reveal the need for any further treatment, pressurization and storage of the statutory water undertaker's supply to meet health building requirements and to enable an estimate of costs to be made.

2.2.3 During the design stage close collaboration with the statutory water authority should be maintained and agreement should be sought to the final arrangements before proceeding with the contract. These arrangements should include:

a. Siting of service connection, access chamber, metering, by-passing, flushing out, physical security of service connection installation and provisions for fire fighting service.

b. Installation design to meet the requirements of the acceptable form of tariff agreement.

c. The recognition of all appropriate byelaws.

2.2.4 Generally and ultimately the byelaws of the statutory water undertaker will conform with the model byelaws issued under the Authority of the Department of the Environment. Where any statutory water authority's byelaws are in the process of any consequential adjustment due to the Water Act 1973, assurance should be sought that any final design complies with such adjustments

2.3 Independent supplies

2.3.1 The exploitation of a source of water supply which is independent of that of a statutory water undertaker, is subject to clearance and any necessary consent under various acts of Parliament and consequential conservation orders. The requirements of the Water Resources Act 1963

and any modifications thereto by the Water Act 1973 must be met and a licence to abstract water obtained from the water authority before embarking on any scheme for an independent supply or for the abstraction of additional quantities of water from an existing independent supply source.

The statutory water authority keeps records and maps of all known existing sources of independent water supply together with details of the geological strata and water bearing characteristics of the area under its control.

2.3.2 Having consulted the statutory water authority and the Institute of Geological Sciences and having decided in which areas, within or adjacent to the proposed hospital site, to explore the prospects of a source of adequate and suitable independent water supply, the next step is to examine those locations where the existence of water is obvious and the yield can readily be measured, such as springs, adits, streams, rivers, canals, lakes or the like. If these prospects prove unsatisfactory due to inadequacy, or untreatable water yield, or excessive cost of installation and treatment, it may be necessary to consider sinking a well or bore-hole, as a last resort. Wells and boreholes can prove expensive as, despite geological advice of good prospects, the yield and recovery rate can only be proved after the boring of a trial hole and it may prove inadequate, and of poor quality.

2.3.3 Wells are generally classified as "shallow" or "deep". A shallow classification generally indicates that it derives its water directly from the superficial layers of the earth's surface and does not pierce a lower impervious stratum which, provided the lining of the well is also resistant to such permeation, should effectively seal off the aquifer against permeation of water from the upper superficial formations. An artesian well is also a deep well, but taps water which is under such pressure by superimposed strata that the water rises under its own energy head to ground surface level. As the water permeates deeper through various strata it eventually reaches an impermeable stratum shaped in the form of a basin which is a good source for a shallow well. In the process of overflowing from this basin the water may continue a flow upwards and under an adjacent impermeable stratum, follow the contour and permeate down to the next impermeable stratum basin, there to form a source for a deep well. This is a continuing process depending on rainfall, catchment area, effluent discharges, permeation from streams, rivers etc. There are instances where the upper edge of a lower impermeable stratum basin may extend to breach the earth's surface effecting a water discharge in the form of a spring or adit. These underground water collections find their own upper water line depending on the shape and location of the stratum basin in which the collection takes place. The characteristics of the water depend on the solubility of the mineral and chemical content and absorption rate of the material through which the water passes, and the consequential contact time. Generally water from underground sources is hard, although the degree of hardness may vary considerably between areas according to the varying nature, chemical and mineral content of the strata through which the water passes.

2.3.4 The yield of water from wells or bore-holes depends on the recovery rate and can only be determined by measuring the water level before and after a test pumping rate over a stipulated time, and noting the time interval for the water level to return to normal. The final designed pumping rate should be kept lower than the recovery rate. Exceeding the recovery rate could lead to erosion within the lower regions of the well and could affect the characteristics of the water; or eventually the total loss of yield.

2.3.5 Having obtained a yield of water it is next necessary to extract average samples for quality analysis. The samples should be analysed as quickly as possible after extraction, by a qualified analyst. Such a service is available by the local public health laboratory analyst. Two samples will be required, one for bacteriological analysis and the other for chemical analysis. The sample for bacteriological analysis is normally required to be packed in ice. The bottles in which the samples are to be collected can usually be obtained from the analyst, who will also provide detailed instructions on the method of taking samples. Sampling techniques are also indicated in the Department of Health and Social Security and Department of the Environment Report No 71 "The Bacteriological examination of water supplies", published by Her Majesty's Stationery Office. Water for domestic purposes in the health service must comply with the requirements of the report, which tabulates in Section iv the standards of quality established in the United Kingdom for the bacteriological requirements of potable water. Publications of interest on this subject have been issued by the United States Public Health Service in 1962 under the title of "Drinking Water Standards" and also by the World Health Organisation under the title "International Standards for Drinking Water".

2.3.6 When an application is made for water to be analyzed the analyst should be advised of the purposes for which the water is required, at the same time he should be given a full description of the source and surrounding environment from which the samples are to be taken. The analyst will from his analysis of samples, give a full description of the water characteristics and advise

on its suitability for the purposes for which the water is required. He will also advise on the treatment necessary and what long term precautions should be observed to detect any subsequent change in characteristics which might arise. The bacteriological analysis is the more important as it will detect impurity when no indication thereof will be given by chemical or other examination.

2.3.7 The yield and character of the water being acceptable, an assessment of capital cost of works and plant installation should be made, together with costs of running and maintenance.

3 Water treatment

3.1. General

3.1.1 The need for water treatment and the method of application depend on the purposes for which the water is to be used and the quantity required for each purpose. Whilst potability is not normally affected by such characteristics as hardness, colour, and within limits smell and/or taste, a measure of treatment may be necessary to provide a more acceptable and wholesome supply.

3.1.2 A supply from a water undertaker should not normally require any further treatment when used for hospital purposes other than for processing for laundries, domestic hot water systems and steam boiler feed water, where either the degree of hardness proves excessive or exceptional softness causes corrosion. Most independent supplies, however, require some measure of treatment and in many cases the installation of pumping and treatment plant needs to be extensive to ensure a constant acceptable quality.

3.2 Impurities in Natural State

3.2.1 Water is not naturally found in a state of chemical purity. In its descent from the clouds it absorbs carbonic acid, ammonia and nitric acid. Surface waters in upland reservoirs, rivers and lakes are often polluted by organic matter such as tree foliage and silt, river water may also be polluted by sewage and industrial effluents and chemicals leached from land drainage etc. Ground waters in springs, wells and boreholes collect impurities from the surrounding strata. Shallow wells collect impurities from surrounding soil.

3.2.2 The impurities which must, therefore, be removed include tree foliage, matter in suspension consisting of mineral particles, minute vegetable growth, various kinds of living organisms and bacteria. Other impurities in solution may also require removal.

3.2.3 Natural filtration takes place as water percolates through the permeable strata and is a good form of disposal of solids in suspension, where such a natural state exists. Suspended matter in water covers a wide range of particle size, the upper limit of which is determined by the degree of turbulence. Particles in lakes and reservoirs are usually in the colloidal range, less than one micron diameter. The physical state of suspended matter is not changed when it is saturated with water.

3.3 Water clarification

3.3.1 This is the general name for the processes mentioned below. There are two basic processes for the removal of suspended matter and colloidal matter:

a. Coagulation, sedimentation and filtration.

b. Filtration.

The choice of process is usually dependent on the nature of the water and the suspended/colloidal matter to be removed. a. is generally used for polluted surface waters (rivers) and for upland impoundments containing dissolved organic matter. b. is normally only used for unpolluted surface waters or ground water which contain suspended solids. A combination of rapid gravity sand filters followed by slow sand filters may be used for polluted surface waters.

3.3.2 If the quantity of matter to be settled out is of a low order in terms of parts per million of the water, filtration only may suffice. Sedimentation takes time, but can be accelerated by mixing-in proportionate amounts of flocculent compound to a specified quantity of water. This treatment is known as coagulation and causes the solid matter to coagulate into heavier particles and settle out more rapidly. Settling basins can, however, be costly as they must be sized to sufficient capacity for the required rate of flow in relation to settling time required to reduce the turbidity. This cost should be compared with that of a bank of filters to give the equivalent result.

3.3.3 Solids in solution cannot be settled out without first changing their state. They consist of matter which is soluble in water and will remain in solution until some form of chemical or heat treatment is applied. Heat treatment is prohibitively expensive. Addition of chemicals in

appropriate proportion to the water and the resultant chemical reaction will cause certain solids in solution to coagulate into solids in suspension which can then be settled or filtered out of the water. This is a much cheaper method than heat treatment. Sedimentation, coagulation and filtration is usually sufficient to remove 90% of bacteria, and practically all the solids in suspension. Micro-organisms should be destroyed by sterilization. (See Section 3.5)

3.4 Filtration

Filters

3.4.1 Filters are of various types and should be selected according to the duty to be performed. The essentials of a filter are that it should be mechanically sound, easy of access for cleaning and of sufficient capacity to treat the required rate of flow without delay or inconvenience. Adequate standby plant should be incorporated into the system for cleaning and maintenance purposes and so inter-connected that any one or more can be taken out of the line for servicing without disturbing the supply of treated water. The filtering medium should be of good quality and readily available.

3.4.2 There are three main types of filter in use, the essential feature of all types being a thick submerged bed of graded sand or anthracite which usually rests on a graded bed of gravel or other suitable material, and over which the raw water is distributed. After passing through the bed, the water is collected by a manifold draining system.

a. In a pressure filter the bed is contained in a closed cylinder, thus enabling the raw water pressure to be used for filtration and subsequent distribution. Pressure filters are usually housed in buildings. For small, temporary or mobile installations a convenient filter is one of the pressure types in which filtration is carried out by the use of a fine grade medium such as diatomaceous earth (kieselguhr), synthetic resins or ceramics. Ceramic filters are usually impregnated with ionic silver which has a strong sterilizing action, making chlorination unnecessary. After sterilization the filtered water may be passed direct to consumers.

b. Rapid gravity filters are constructed either in buildings or outdoors, but if outdoors it is usual to enclose the operating valve galleries. The filtration is carried out at atmospheric pressure in open basins, usually of concrete.

c. A slow sand filter requires a relatively large surface area, but when properly maintained can be highly efficient. Because of their large size and high cleaning costs they are unlikely to be used in the health service although they are much used in the water supply industry.

3.4.3 The filter bed offers increasing resistance to flow, due to the interception of impurities and when this resistance reaches a predetermined value the bed will require cleaning. This is normally accomplished in pressure and rapid gravity filters by breaking up the aggregates with mechanically operated stirrers or by compressed air, followed by washing out of the impurities by means of a reverse flow of fully treated water. In a slow sand filter, the top layer of sand, together with the intercepted impurities, is removed periodically either by hand or mechanically. The bed is then raked level and the filter is put back into service. After a period depending on the amount of sand removed in this way, sufficient clean washed sand is added to restore the bed to its original level, the original bottom sand being lifted and placed on top.

3.4.4 Water for washing the filters should be filtered water. This water is required at a rate considerably in excess of the rate of filtration, and where there is only one filter unit it is necessary to take the wash water from storage. An elevated storage cistern provides for filter washing by gravity flow and, for a pressure filter, can be charged directly from the outlet of the filter, but for a gravity filter, the cistern has to be charged by pumping. Where the storage cistern is at ground level, wash water is pumped through the filter, whether of pressure or gravity type. Where there are multiple filter units it may be possible to do without wash water storage.

3.5 Sterilization

General

3.5.1 Normally a supply from a statutory water authority should not require sterilization, but all piping, fittings and associated services used for a conveyance of water for domestic purposes must be sterilized before being brought into use. Independent water supplies must be sterilized before being used for domestic purposes. Bacteria are not killed by freezing nor by the use of antiseptics, such treatment only inhibits their development. Sterilization is effected by chemical or physical agents. The method generally used is that of chlorination although ozonization is also very effective.

Simple chlorination

3.5.2 When the water does not contain much organic matter or other impurities a small quantity of chlorine is added to maintain a bacteriologically safe water. It is usually applied to

supplies of satisfactory purity as a precautionary measure.

Chlorine—ammonia process

3.5.3 This process is also referred to as the *chloramine* process since it forms chloramines, the bacteriological action of which is slower than that of free chlorine, but remains effective for a longer period. This process can be used with advantage when the treated water is retained for long periods in service reservoirs and mains before delivery. The ratio of chlorine to ammonia is approximately 4 to 1. The ammonia is usually added after the chlorine to allow time for the chlorine to act. If improvement of the taste or the removal of odour is the main object, ammonia is used before chlorine. The reaction between chlorine and ammonia produces residuals in the form of chloramines, which are mild disenfectants. They are less active chemically and less likely to form chlorinous tastes. The slower disinfecting action of chloramines more than nullifies their favourable non-taste-forming characteristics. Chlorine-ammonia treatment has, therefore, not been used to any great extent since the development of super chlorination.

Super chlorination and dechlorination

3.5.4 This method is widely practised. It is particularly suitable for a well or borehole supply where there is a danger of intermittent pollution; for example, after a heavy downpour of rain. It consists of dosing the water with chlorine in excess of the amount required for sterilization and then reducing the residual chlorine in the water, to whatever level is desired, by adding either sulphur dioxide, sodium thiosulphate or sodium sulphite.

Break point chlorination

3.5.5 This method is a development of the superchlorination process. The term "break-point" refers to the stage of the process where residual chlorine in the water decreases to the minimum and then commences to increase at a rate proportional to the chlorine added. The break point is particularly pronounced in a water containing ammonia. The advantage of applying a dose of chlorine high enough to pass beyond the break point is that in addition to more effective sterilization it prevents the formation of tastes and odours or where these are present removes them.

Time required for various chlorination processes

3.5.6 The processes indicated depend for their efficiency on the maintenance of a sufficient period of contact between the sterilizing agent and the water. The normal contact time required between points of dosing and draw off is as follows:

Simple chlorination—at least 30 minutes.
Chloramine—at least 24 hours.
Superchlorination and dechlorination—usually about 30 minutes.
Break-point—usually about 2 hours.

Ozone

3.5.7 In the case of most waters, the introduction of ozone is a very effective method of sterilization. It also reduces taste, odours and colour and increases the palatability of the water. However, the cost of producing ozone at present is such that this method would not normally be justified in the health service for water sterilization.

3.6 Water softening

3.6.1 Hard waters are sometimes unsuitable for many industrial and domestic purposes. Treatment may, therefore, be necessary to remove or alter the constituents to render the water suitable for particular purposes. A simple test may be made, to ascertain if water has some measure of hardness, by trying to make a lather from soap immersed in the water. The harder the water the more soap is destroyed before the lather will develop.

3.6.2 Hardness is due to calcium and magnesium salts in the water, expressed in terms of milligrammes per litre as calcium carbonate (Ca CO_3). Temporary (carbonate) hardness is the bicarbonate salts of calcium and magnesium. Permanent (non-carbonate) hardness is the other salts of calcium and magnesium, ie chlorides, sulphates, nitrates etc. The generally accepted classification of waters is as follows:

	Milligrammes per litre (mg/l) as Ca CO_3
Soft	0 to 50
Moderately soft	50 to 100
Slightly hard	100 to 150
Moderately hard	150 to 200
Hard	200 to 300
Very hard	Over 300

3.6.3 When water is boiled the hardness will be reduced by some of the dissolved salts (temporary hardness) coming out of solution and forming solids in suspension, some of which will be deposited on heating surfaces to form an adherent lime scale, thus reducing the heat transfer rate. Any process in which water has to be brought near or higher than boiling temperature would be subject to this change and the efficiency of the process would be impaired.

3.6.4 The extent of treatment required to prevent scale formation would depend upon the process for which the water is being heated; it

may, therefore, be necessary to achieve one of the following conditions:—

a. Removal of calcium and magnesium salts.

b. Conversion of calcium and magnesium salts to salts of sodium.

c. A combination of a. and b.

d. Removal of all salts, ie demineralization.

3.6.5 In some instances physical or chemical treatment before the process of use can be effective: for example, pre-treatment of feed water to a steam raising boiler can reduce the deposit of lime scale within the boiler and will produce instead a slurry which does not adhere and may, therefore, be removed by blow down.

3.6.6 Softening is not considered necessary for palatability. In some instances the softening process makes the water less palatable without affecting the potability. The following is an extract from the CMO's Report, 1975, Page 36:—

> "Despite intensive epidemiological investigations in recent years, it is still not known whether the differences in mortality are associated with a toxic factor in soft water, a protective factor in hard water, or whether some other environmental factor is involved. As a general principle it is better for the health to drink hard water despite the drawbacks of using such water for domestic washing and cleaning."

3.6.7 The implications of the available evidence are summarized in "Prevention of Coronary Heart Disease"—Report of a Joint Working Party of the Royal College of Physicians of London and the British Cardiac Society, 1976, which states:—

> "12.6 Water hardness and other mineral factors
>
> 1. In the United Kingdom, death rates from cardiovascular disease are higher in areas with a soft water supply and lower in those with hard water. Cardiovascular disease mortality is low in the south-east of England where water is predominantly hard and high in the north and the west, where drinking water is predominantly soft; the mortality rates are about 40 per cent higher in the very soft water towns compared with very hard water towns. There is no claim made that the mineral content of drinking water is the major determinant of cardiovascular disease in the United Kingdom or elsewhere, but only that there may be an important relationship between the hardness of drinking water and the regional variation in the frequency of heart attacks and strokes.
>
> 2. The strongest association between cardiovascular disease mortality and known substances in the water supply is with calcium. However, soft waters, being more acid, are likely to dissolve potentially toxic trace elements from soils or from distribution systems, and several trace elements are suspected of being involved in coronary heart disease, eg lead, calcium and chromium. Although there is some evidence concerning the relationship between cadmium and hypertension there is at present no firm evidence linking trace elements in drinking water to coronary heart disease.
>
> 3. Despite the strength of the statistical association between water hardness and cardiovascular mortality in the United Kingdom, we do not know that this relationship is a direct and causal one. If there is a 'water factor' its identity and its mechanism of action are not known. Nevertheless, the association is a very strong one and it would, therefore, seem prudent in the present state of our knowledge not to soften public drinking water unless there is some overwhelming reason for doing so and then only to do so moderately. Where domestic water softeners are used, it might be prudent for drinking water to be taken from the mains supply."

3.6.8 Until further medical evidence makes the position clear, engineers should ensure that in any new scheme or installation, drinking water points are not connected to the softened water supply system. But in the case of existing installations where drinking water supplies are already taken from the softened water supply system, action to change the supply is not at present required.

3.6.9 Waters having a hardness of up to 400 mg/l have been used for public supplies without preliminary softening. Whilst it is accepted that supplies for domestic purposes need not be softened many water authorities do in fact carry out partial softening.

3.6.10 The need for softened water in hospitals for domestic purposes other than drinking and cooking should be considered on the merits of each case and if treatment is considered essential the hardness should be to a degree acceptable to users. The value found to be generally acceptable is between 80 and 150 mg/l, but this should not be taken as a requirement for hospitals as it may be impracticable to achieve. The cost and difficulties of treatment may be prohibitive for certain waters if the hardness value is particularly high and the content of magnesium is appreciable.

3.6.11 Generally, in the health service, softening of a hard water supply will be required on feeds to the following:—

a. Boilers and hot water supply—to prevent sludge and lime scale building up in pipework and plant. (See B.S.2486–1954 "Treatment of Water for Land Boilers").

b. Spray taps and blending valves—to avoid clogging by lime scale of control ports and fine spray orifices.

c. Spinning disc humidifiers—dust problems can occur from the air supply to occupied areas. When atomized water droplets evaporate, the totally dissolved solids remain in the air-stream as fine dust. To be effective the water treatment used must remove these solids and not just change their chemical composition as occurs in a base exchange system.

d. Cooling towers—to alleviate the problems of scaling of fan blades and silt build-up caused by high evaporation rates and the chemical pick-up from polluted air entrainments.

e. Laundries—high maintenance costs and the uneconomic use of soap or detergents are caused by the presence of hardness. (See Health Building Note No 25—Laundry).

3.6.12 Before considering the softening process, and subject to the water service being limited to domestic purposes only, it should be possible to adopt another form of treatment which, while it discourages scale formation, does not soften the water and soap consumption is not reduced. The substance employed is a slowly soluble form of phosphate known as "glass" and it can be used in an enclosed pressure vessel which can be fitted in the water supply pipe line, so that all the water passing through this line will make contact with the phosphate and so stabilize the hardening salts to remain in solution. By installing the phosphate dispenser in a valved by-pass, recharging of the dispenser can be performed with little or no inconvenience. There are other available treatments of an electrical or magnetic nature.

3.7 Water Softening Processes

General

3.7.1 Softening is effected either by the precipitation of the hardness elements, as in the lime or lime-soda processes, or by changing their nature, as in the ion exchange processes.

Lime and lime-soda processes

3.7.2 These processes are employed for the removal of both permanent and temporary hardness. The addition of lime and soda ash to the water causes the calcium and magnesium content to precipitate out as insoluble forms that can be removed by settlement and/or filtration. The lime process is more common and removes temporary hardness. The lime-soda process removes both temporary and permanent hardness. As in the case of the filtration plant referred to earlier, final removal of the precipitate may be preceded by coagulation and sedimentation chambers. A disadvantage of these processes on major installations is the large amount of sludge that results and the difficulty of disposal, particularly in built-up areas. Remaining hardness will depend on quantity of chemicals added. pH values are normally corrected to 7·5 by use of CO_2 or acid.

The pellet reactor process of softening

3.7.3 In this process water treated with lime is passed to a vessel shaped as an inverted cone and containing grains of a catalyst. The water flows upwards spirally and holds the grains in suspension. The temporary hardness compounds are deposited on the grains by catalytic action. The grains increase in size until they can no longer be held in suspension and fall to the base of the vessel: sludge in this form is disposed of easily. This process removes only the temporary hardness.

Ion exchange processes

3.7.4 In this process the calcium and magnesium salts are exchanged for the corresponding sodium salts which are not "hard" in effect. To perform the function a closed pressure vessel is charged with the mineral zeolite, or a cation exchange resin in the sodium form, which changes the hardness salts in water into sodium salts. The natural mineral zeolite is no longer used, it has been replaced by the synthetic ion exchange resins. In due time the zeolite or resin becomes converted to the calcium form at which stage it ceases to perform any exchange process. The zeolite or resin can, however, be conveniently regenerated to its original sodium form by passing a solution of brine (sodium chloride) through it. When all the excess brine has been back flushed from the zeolite or resin it is ready to repeat the original exchange process. The product of ion exchange softening is a water of hardness very close to zero. Unlike the lime-soda process the ion exchange process cannot be applied to turbid acid or ferruginous water as it would lose its efficiency and irreversible damage may be done. To obtain a water of hardness 60–150 mg/l, usually 100 mg/l approximately, the treated water has to be blended with the appropriate quantity of untreated water. Zero hardness water can lead to corrosion and if used for steam boiler feed water, pre-treatment by using appropriate chemicals will be essential to avoid damage to boiler plant. The

ion exchange process is almost free from moving parts, occupies less space than the lime or lime soda process for the equivalent capacity, and operating costs are also lower than for the lime soda process.

Hydrogen-ion exchange

3.7.5 A cation exchange resin in the hydrogen form is used to exchange cations (calcium, magnesium, sodium etc) in the water for hydrogen ions. The effect of this is to convert the dissolved salts in the water to their corresponding acids (carbonic acid, hydrochloric acid, sulphuric acid etc). The water is therefore *acid* in character, and *cannot* be used for any ordinary purpose without further treatment. This water may be treated as follows:—

a. Blended with base ion exchanged water for the purpose of reducing the sodium bicarbonate alkalinity (high sodium bicarbonate natural waters may also be blended). This process liberates carbon dioxide which must be removed by aeration. The complete process is known as dealkalization.

b. Blended with lime or lime-soda softened water.

c. The acidic water may be passed through an anion exchange resin in the hydroxide form in which case the anions (chloride, sulphate etc) are exchanged for hydroxide. The complete process is known as demineralization.

The cation material is regenerated by a weak solution of sulphuric or hydrochloric acid and the anion material is regenerated by a solution of caustic soda. The effluent from regeneration must, as with other processes, comply with the requirements of water authority bye-laws and this is an important factor in the design of the demineralization unit.

The system selection depends on the service required. In some services such as boiler plant, particularly the modern packaged type, high alkalinities and dissolved solids in the boiler water cannot be tolerated. Complete removal of dissolved solids by de-ionization would not be economic, but partial removal of alkalinity (dealkalization) using a hydrogen exchange unit, in conjunction with a zeolite base exchange softener, would give an acceptable water. In modern steam or high pressure boilers it is essential to eliminate dissolved oxygen from boiler water and feed water, to prevent boiler and feed line corrosion. It is necessary therefore to deaerate the water after softening, by a mechanical deaeration unit which does not increase the total dissolved solids in the boiler. Further chemical dosing may also be necessary.

Mixed-bed demineralization

3.7.6 A high quality water can be produced by using a mixed-bed cation/anion exchanger. There are large scale mixed-bed units in which the mixed resins are separated for re-generation. For the water to be medically sterile, further heat distillation treatment is necessary. Before any scheme is set up to produce water for clinical or pharmaceutical purposes in connection with the health service, advice on the acceptability of the proposals must be sought from the appropriate Regional Pharmaceutical Officer, who will be conversant with the current requirements of the Medicines Act, and the British Pharmacopoeia Standards 1958, for purified waters. The installation of a permanent mixed-bed cation/anion plant will depend on the type of health building and uses for which the water is required. A specific quantity is required for each purpose and in some instances storage may be necessary. Some of the medical applications will be so critical that great care must be exercised to ensure that any installation, storage and conveyance system, must be designed and used so as to prevent any form of contaminant permeation due to depreciation, poor maintenance, and misdirected handling. Careful sterilization should be practised at all stages of application.

3.7.7 *Reverse osmosis* can be used as a pretreatment for deionization for raw water with a high total dissolved solids content or contaminated with organic material. Removal of organic compounds and up to 90% of inorganic salts is achieved by forcing the water through a semi-permeable membrane in the opposite direction to normal osmotic diffusion.

3.8 Miscellaneous treatment methods

Removal of colour tastes and odour

3.8.1 Reference has already been made to chlorination and ozone processes as being effective for this purpose.

Activated carbon treatment

3.8.2 Activated carbon in powdered or granulated form removes, colour, tastes and odours. For powdered carbon the point of treatment should precede mixing and sedimentation tanks or filtration. Granular carbon is used in terminal filters. Dosage can be intermittent in the range 8 to 20 mg/l or continuous at about 3 mg/l.

Aeration

3.8.3 Aeration is used to promote gas transfer to and from water. Its principal use is to remove sulphuretted hydrogen from water derived from deep boreholes or wells, but it also can be used to lower the CO_2 content of the water and thus its corrosiveness. When iron is present in solution as

ferrous bicarbonate, aeration can convert the iron from a soluble to an insoluble state such that it precipitates out as a red brown deposit of ferric hydroxide, which is removable by sedimentation or filtration. Aeration is seldom successful when taste is due to pollution by organic matter, however, it can sometimes improve the appearance of water which is stagnant or of limited palatability.

Fluoridation

3.8.4 The then Minister of Health first commended fluoridation to local health authorities in 1962, after the publication of a report on the results of fluoridation studies in the United Kingdom after five years (Reports on Public Health and Medical Subjects No 105 HMSO 1962). The decision of implementation and the installation and running costs of fluoridation plant is the responsibility of the Area Health Authority. If a Health Authority decides in favour of fluoridation, the Government expects the Regional Water Authority concerned to give effect to this decision as soon as is reasonably possible, provided this is acceptable to any other Health Authority whose area would receive supplies of the fluoridated water. Maps showing the boundaries of the Regional Health Authorities and the Regional Water Authorities are included in Appendix 6.

3.8.5 Advice on the equipment to be used is supplied by the Department of the Environment (DIV DGWE 2 Marsham Street, London SW1P 3EB) which is also responsible for the surveillance of the monitoring of the dosing plant during the initial testing period. The keeping of daily records of fluoride levels is the responsibility of the statutory water authority, and these are forwarded to the Department of the Environment during the initial six months' surveillance. After six months' continuous trouble free running a clearance certificate will be issued. The surveillance then becomes the responsibility of the Area Medical Officer who should advise the Department of the Environment if the fluoride limits vary outside the stated figures of 1·0±0·1 mg/l.

3.8.6 Normally fluoridation will not need to be carried out where a health building has its own source of water supply as it will be of little benefit to patients during their limited stay in hospital. Should fluoridation be thought necessary in certain circumstances, strict daily records must be kept to ensure that the dosage is limited to the maximum of 1 mg/l calculated as fluoride in the water going to supply, including the amount of fluoride occurring naturally in the water. The procedure of surveillance of the daily records will still apply as laid down in the previous paragraph.

3.9 Corrosion and its prevention

Causes of corrosion

3.9.1 Corrosion due to causes other than the bacteriological or chemical properties of the water will be dealt with elsewhere. Such causes may include the motion of the water or electrolytic action.

3.9.2 Water supplied by the various water undertakers although remaining uniformly potable will, nevertheless, differ chemically. Some waters are slightly acidic whilst others are slightly alkaline and this affects the choice of materials for pipes, fittings and cisterns. It will, therefore be necessary to consult the water authority in whose area the health building complex is to be sited for advice on what materials should be avoided.

3.9.3 The most common cause of corrosion is low pH (acidic) waters which may be derived from peaty soils as in many upland sources or from underground sources in the form of free carbon dioxide. Brass and copper are attacked by ammonia which may be present in polluted river water or in water sterilized by chloramine treatment (a process rarely used today). Soft waters may dissolve lead and may also cause pitting in copper pipes. Dezincification of certain types of brass can occur with waters of a high chloride to temporary hardness ratio and a pH of above 8·2.

3.9.4 The principal properties of a water likely to cause corrosion are:—

a. High content of chloride or other salts in which the pH value is normally raised.

b. Acidity due to excess carbon dioxide content of the water which is the main cause, ie low pH waters.

3.9.5 The combined effect will depend on whether the water is "balanced", ie if it is in equilibrium with solid calcium carbonate, since it will then be non-corrosive. Some indication as to whether a water will be corrosive or not is obtained from the Langelier Index. The Langelier Index is the difference between the pH obtained from the "chalk test" and the actual pH of the water. A negative figure indicates an excess of carbon dioxide, and potentially corrosive properties and a positive value indicates a tendency to deposit scale.

3.9.6 Corrosion may cause heavy replacement costs where water with corrosive properties is conveyed and used. In the process of treatment to reduce hardness, corrosive tendencies can develop. To reduce corrosion, treatment by aeration, pH adjustment and formation of a protective film by controlled deposition of calcium carbon-

ate or by addition of corrosion inhibitors is necessary.

3.9.7 Aeration will reduce the free carbon-dioxide content, but increase the oxygen content, but as noted earlier, de-aeration of water for boilers is required.

Corrosion prevention

3.9.8 Where the water supply is likely to be corrosive towards the materials of construction of the systems its corrosive tendencies may be reduced by:—

a. pH adjustment (increase) by eg addition of sodium carbonate (soda ash) or other alkali. This will neutralize organic acids and free carbon dioxide.

b. pH adjustment plus increase in hardness/alkalinity by eg addition of lime or by passing the water through a bed of marble or limestone. This is better than action as in (a).

c. The use of corrosion inhibitors such as sodium silicate or sodium hexametaphosphate.

3.10 Metal contamination

3.10.1 Analytical results have shown that there can be a serious problem from lead or copper contamination of hospital water supplies. In general terms if hospital drinking water contains more than 0·05 mg/l of lead or 1 mg/l of copper then remedial action will be necessary. In addition it must be ensured that supplies to certain specialist units are not contaminated by copper or heavy metals in excess of 0·05 mg/l.

3.10.2 The specialist units to which these standards apply are maternity, neo-natal paediatric, general paediatric and renal dialysis units. Water containing excess quantities of metal may aggravate skin conditions in infants and should not be used in infant food preparation.

3.10.3 Where the water supply is known to be aggressive, regular sampling tests should be made at the terminal units to ascertain that the level of metal contamination in the water supply to the hospital plus any added during its passage through the hospital distribution system does not result in limits above the stated safe levels. This will specially apply if the hospital distribution pipework consists of hard drawn thin walled copper with a multiplicity of soldered (capillary) joints. (See Appendix 5.) In soft water areas, metal contamination can occur by the water attacking the solder joints. In hard water areas the copper will pit and corrode if the deleterious carbonaceous residue that can be left by the drawing lubricant is not removed.

3.10.4 Where the proposed water supply is likely to pick up or contain lead and/or copper in excess of acceptable limits it will be necessary to consider using an alternative water supply, or treatment of the water.

3.11 Flushing of mains

Bad taste, odours and discolouration due to iron can develop in water which tends to stagnate at ends of distribution mains. Much care should be exercised at design stage to ensure that stagnation can be reduced or avoided by including often used draw-off points at dead end points in the network. If this is not always possible a flushing point should be included for operation during a planned maintenance routine.

4 Water storage

4.1 General

The three principal reasons for the storage of water are:—

a. A means to provide an economic balance between the source of supply and fluctuating demand.

b. The provision of an adequate reserve to meet hospital requirements in the event of an interruption to the supply.

c. Fire fighting service.

4.2 Extent of storage

4.2.1 Storage, from the viewpoint of obtaining an economic balance, reduces the maximum rate of demand on the mains and limits the pressure on the distribution and service pipes and fittings and therefore may enable lighter gauge piping to be installed, although this benefit is seldom realized in practice. It also tends to reduce noise and the risk of a waste of water.

4.2.2 Storage should be calculated on the requirements of peak demand and the rate of make up from source of supply. There may be more than one peak period in each 24 hours. The interval between peak periods is important as it determines the amount of make up that can be expected and the shut down time for maintenance, if twin cisterns are not used. The overall health building complex may comprise:—

a. One building housing one or more ward units together with supporting services.

b. Several buildings each with one or more ward units together with common supporting services.

c. Several buildings each containing a different type of health building unit together with buildings containing common supporting services.

4.2.3 The average daily consumption of probable usage for a health building is a matter of calculation based on the flow of water available at the fittings and appliances installed in each department in relation to the numbers of patients and staff. This usage will take into account the number of fittings and appliances which may be used simultaneously, so that storage cisterns catering for a department or group of departments will be designed to meet these requirements and, therefore, provide the economic balance between the supply to the cisterns and fluctuations in demand from the department.

4.2.4 The Hospital Engineering Research Unit carried out a study of water consumption for a number of wards in existing health buildings, in conjunction with the Department of Health and Social Security. Appendix 1 to this memorandum is based on the results of this study. On this basis, whilst it is accepted that the desirable minimum for total storage will vary with the classification of the particular health building, the upper limit of storage for a District General Hospital is 900 litres per bed per day and for a teaching hospital 1350 litres per bed per day, excluding provision for the staff residences, laundries and any special storage for fire fighting purposes.

4.2.5 A summation of the average daily consumption for each ward unit contained in a building should be made. From the requirements of each building the policy of water storage for the whole complex should be decided. It does not always follow that peak demands for each building will coincide and therefore there may be scope for applying a diversity factor to the whole site.

4.2.6 Where the water requirement is to be met from an independent supply, the summation for each building may require assessment on the basis of storing and using water according to the minimum treatment of the water for each particular use. Likewise where the water is hard enough to require softening for certain domestic and/or laundry purposes, separate storage will be required and this should be taken into account when assessing the total stored water.

4.2.7 Appendix 1 (sheet 1) does not cater for water requirements for staff quarters or such support services as laundries, bulk stores, transport garages and workshops etc. Water requirements for fire fighting are also excluded but are dealt with in section 5.16 on fire. The Staff quarters and industrial areas may be remote from the main hospital and supporting departments. The laundry may serve a number of health buildings as well as the health building at which it is located. The storage requirement for such accommodation should therefore be calculated separately and integrated with the accommodation whenever this is practical. Appendix 1 sheet 7 provides data on typical demands expected from staff residences.

4.3 Contingency supplies

4.3.1 Provision should also be made in the assessment of the total stored water requirement for contingency, where there is any doubt as to the continuity and maintenance of a minimum rate of flow of the water supply.

4.3.2 Where a health building complex water requirement cannot be met by the statutory water undertakers and is supplied from an independent supply which, because of certain limitations, is not suitable to meet any contingency within its own make up, there may be a need to seek a contingency supply from the statutory water undertakers. The feasibility of such a connection depends largely on the source of water supply and distribution systems of the statutory water undertakers.

4.3.3 A failure in the Water Authority source of supply, such as an impounding of a reservoir or borehole, is less likely than a breakdown in the distribution system; therefore, the extent of contingency storage to be provided will need to be based on such factors as the reliability and extent of the statutory water undertaker's trunk distribution system, the demands on the system from other consumers, interconnecting arrangements between the trunk mains, the number of distribution zones and the interlinking arrangements of the zone from which the health building is to be supplied. It is essential that, if detailed consultation is to be carried out with the statutory water undertakers, their advice on the time element for contingency storage should be very carefully considered. Normally contingency storage should be provided for water consumption over a period of 24 hours.

4.3.4 Where a health building complex, in the interest of economy or other justifying reason, uses an independent supply, it is still advisable if possible to obtain an alternative supply from the statutory water undertakers. Whilst the statutory water undertakers' byelaws do not permit physical interconnection of the two supplies, the requirements of the byelaws will be met if there is an air space of at least 152 mm between the discharge point of the water undertakers' supply and the top of the storage cistern into which the independent supply water is being discharged.

4.4 Location and form of storage

General

4.4.1 The location of storage will depend on the extent of the storage required, the topography and layout of the site proposed for development, the sources and adequacy of the water supply. A limited site may call for much higher buildings to achieve the required accommodation. To this restriction might be added an insufficient water pressure thus leading to more fragmentation of storage and considerable increase in pressurizing equipment. The cost of the supporting structure will have an important bearing on the solution adopted.

4.4.2 A hospital built on a restricted site might need both central and local storage to be provided in each building or in one of the buildings to serve other buildings in the development. Local storage at high level should give about 8 hours' average supply or one third of a day's supply if gravity fed, but if the building structure will economically accept more tankage this should be used. The balance of 24 hours, ie two thirds supply should be provided in central storage at high or low level depending on economics and other factors.

4.4.3 Where such storage is located in individual buildings and an adequate supply is available from the statutory water undertaker, a connection in accordance with the statutory water undertaker's byelaws to each point of storage may be the most economical arrangement. In such cases interconnections between selected points of storage should be provided to deal with emergencies and maintenance reqirements. Where the development is widespread and a statutory water undertaker's multiple connections are not the best solution, the general arrangement might consist of a total storage reservoir, strategically sited, and serving cisterns located as conveniently as possible to the major centres of usage. The alternatives available for the location and design of the reservoir will vary from the installation of a water tower to the construction of the unit either below or at ground level.

4.4.4 The final assessment of the capacities of storage cisterns will emerge from the design requirements of Appendix 1. The architect's structural design will influence the number of cisterns required and the cistern layout planning necessary to meet the total tankage. Generally manufactured standards should be applied where possible and practicable. Specials should be avoided as they are usually more expensive. Cisterns must not be located in any position where there is any likelihood of flooding or any other threat of contamination, affecting the contents of the cisterns.

4.5 External storage

4.5.1 The ideal location is the roof of the highest building, providing the structural design can support the load. Concrete water cisterns should be designed to form an integral part of the building.

4.5.2 Where storage is below ground, as distinct from being housed within a building, it is most important to ensure that there is no risk of contamination from adjacent sources. Investigations of such risk require careful consideration of site conditions and should include such aspects as flooding, subsidence, the location of sewers and drains and other buried services, the maximum and minimum height of the water table in the area, the natural drainage of surface water and, in the event of storage below a car parking area or roads, the danger of oil seepage. The future development of the health building and probable extensions should also be taken into account in this respect.

4.5.3 Storage below ground should be accepted only in the last resort and a metal cistern in such a situation must be installed within a chamber allowing sufficient space around and beneath the storage vessel to permit inspection and maintenance. Any underground construction arrangement, concrete or otherwise, not directly against earth will reduce the risk of contamination. The tank chamber must include provision for a sump to collect drainage water and any piping necessary to pump out cisterns to site drainage.

4.5.4 The economic depth for reservoirs constructed in concrete is a function of the quantities to be stored. It should be considered at the outset of the planning stage and will be influenced by soil bearing characteristics of the locality and take account of the outlet main's position and particulars. Normally where concrete reservoirs are used in the National Health Service it is not anticipated that the quantity of water stored will merit a depth in excess of 3·6 metres. If it is found necessary to exceed this depth a specialist should be consulted. A rectangular or square concrete reservoir will generally provide a more economical proposition than one or more circular reservoirs.

4.6 Internal storage

4.6.1 As in the case of external storage, cisterns should be installed in positions where they can be readily inspected and maintained and where they will not be affected by frost or high temperatures.

4.6.2 If cast-iron or pressed steel cisterns are selected, designs with external assembly flanges are suitable for use where a plain internal surface

is necessary or where there are no restrictions in the way of access around the cisterns. It is essential in all cases that there is a clear working space of not less than 1 metre around and over the cistern to facilitate erection, inspection and maintenance. An additional allowance must be made for valves or other external fittings. A minimum of 0·5 metres should be provided between the floor of the catchment basin and the underside of the cistern. Units with internal assembly flanges provide a better appearance when erected above ground in conspicuous situations but present difficulty when the need arises to completely drain the cistern.

4.6.3 Roof spaces in which cisterns are to be installed must have adequate trapdoors or other means of access, to facilitate inspection and maintenance. If the roof space or other location for water storage cisterns is liable to the action of frost, the cisterns should be provided with thermal insulating material to cover the top and sides, with the top part of the insulation conveniently removable, where necessary.

4.6.4 Cisterns should be adequately supported on bearers placed under the longitudinal or lateral tank plate joints in such a way that water condensing on the side of the cistern may drain off without causing corrosion to the bottom of the unit. The design should incorporate a catchment tray under the cistern to contain condensed water or leakage, so as to avoid damage to accommodation below. The floor of the catchment tray should be graded to a drainage sump complete with drain pipe. Special requirements apply to the supporting of glass-reinforced plastic sectional cisterns on bearers and manufacturers' recommendations should be observed.

4.7 Construction of cisterns

4.7.1 Appendix 2 gives general guidance on cistern selection, shape, material and cistern room layouts.

4.7.2 Depending on size and/or capacity, tankage should be divided into convenient compartments suitably interconnected and valved to facilitate cleaning, sterilizing, repairing, modifying and inspection, without seriously disturbing tankage service.

4.7.3 Normally the materials used for storage cisterns serving health buildings are concrete, steel or cast-iron. Asbestos cement and glass-reinforced plastic (GRP) should also be considered. The material selected should resist any action due to the quality of the water stored.

4.7.4 With mass and/or reinforced concrete as the material there is no upper limit to the dimensions of structures for the storage of water. It is considered to be the most economical medium for underground cisterns or reservoirs for health buildings when such units are constructed in direct contact with the surrounding ground. Such a storage cistern has an economic advantage over steel or cast-iron when the cistern forms part of the buildings as, apart from other factors affecting economics, integration with the structure disposes of the need for a cistern room.

4.7.5 Building movement has been experienced in some cases and precautions against this must be taken in the constructional design. Precautions will be required to ensure that the combined water storage and building loads fall within the permissible bearing capacity of the ground since any movement under these circumstances could be both expensive and inconvenient to repair.

4.7.6 Where concrete structures are constructed directly against the soil, special safeguards may be necessary depending on the chemical analysis of the soil and ground water. Sulphate resisting cements or other precautions may be necessary in certain circumstances. For further information refer to BRS Digest 90: February 1968—Concrete Sulphate-Bearing Soils and Ground Waters, and CP 2007—Design and Construction of Reinforced and Prestressed Structures for the Storage of Water and other Aqueous Liquids.

4.7.7 Where the water to be stored tends to be corrosive it may be of advantage to increase the cement content of the mix and to increase the cover to the steel used for reinforcement. Additionally, the provision of an impermeable protective lining will be necessary.

4.7.8 The choice between cast-iron or steel for central storage or for local storage cisterns is usually a question of initial capital cost. Assuming the weight of cast-iron is not a significant factor, its longer life and lower incidence of maintenance favours its selection.

4.7.9 Cast-iron or steel cisterns located externally may be protected against pollution by being installed in a well ventilated but draughtproof housing constructed so as to prevent the ingress of birds, rodents, and insects. The cistern itself should be a closed vessel with a tightly fitting access cover bolted into position and any pipe open to atmosphere should be suitably screened. The housing accommodating the cistern must be designed to permit easy access for inspection and maintenance. In exposed positions liable to frost, all cisterns and associated pipework should be adequately lagged and protected with a waterproof covering.

4.7.10 Sectional cisterns fabricated from cast-iron or pressed steel provide a convenient

means of bulk storage of water not under pressure. The components can be readily transported to site and, subject to unit multiples, they can be erected to give varying proportions of length to breadth and depth. It is also possible to make provision for future extension in capacity by an increase in available floor area or, within limits, depth. Units with either internal or external flanges can be provided. In general cast-iron cisterns are still available in sizes up to 40 ft × 40 ft × 12 ft deep fabricated from unit plates 2 ft, 3 ft or 4 ft square (at present manufacturers of CI sectional cisterns are adhering to Imperial dimensions). Pressed steel sections sectional constructed either of hot or cold pressed plates are available in sizes up to 52 ft × 52 ft × 16 ft deep and made from standard plates 4 ft square, or 13 metres × 13 metres × 5 metres deep and made from plates 1 metre square. The actual capacity (to water line) of storage cisterns fabricated from galvanized mild steel to BS417 is limited to 3364 litres. Cast-iron and steel cisterns should be lined or coated with a non-toxic bituminous compound which will not result in imparting a taste or odour to the water. Alternatively steel cisterns may be galvanized.

4.7.11 The cost of sectional cisterns manufactured in GRP is nearer that of steel than of cast-iron. With the added advantages of light weight and virtually no maintenance, a longer life is claimed for this material than for an equivalent unit fabricated from steel. The capacity of cisterns formed in GRP sections is limited by manufacturing availability and lack of experience of use of multiple section high capacity units. The sizes covered by a British Standard Specification are limited; therefore, the use of cistern sizes outside BSS are not recommended in health buildings for the present. GRP panels to BSS limit the height of cisterns to 1·8 metres. GRP cisterns of heights above 1·8 metres will require panel support from external steel corsetry.

4.7.12 Asbestos cisterns and pipes are acceptable as they do not contain "blue" asbestos fibre but manufacturers must plainly label all asbestos products as a safeguard warning against dust inhalation when cutting is required. The actual capacity (to water line) is limited by B.S.2777 to 701 litres.

4.7.13 Storage consisting of more than one cistern or a compartmented cistern should be interconnected as indicated in Appendix 2. Each storage cistern and each compartment of a compartmented cistern should be provided with the following:

a. An internal access ladder, as necessary.

b. A *full way* type of isolating valve at each inlet and outlet connection. The outlet connection should be at least 75 mm but not more than 125 mm above the floor of the cistern to accommodate any precipitate which might accumulate, and at the end opposite the inlet to avoid stagnation of the water. This particularly applies to large cisterns.

c. A washout connection complete with isolating valve. The invert of the washout connection should be positioned so as to provide maximum drainage of the cistern.

d. An overflow pipe to serve also as a warning pipe. The internal diameter of the overflow pipe should not be less than twice that of the inlet pipe and in any event not less than 32 mm. It should be installed to have a fall of not less than 1 in 10. Its outlet should be in an exposed and conspicuous position so that any discharge of water from it can be seen. The discharge should be visible within the cistern room, although so controlled and contained that no damage can arise. Overflow pipes should be taken to a common sump formed with a catchment basin over which the cistern should be located. The possible need for lagging and bird-screening must be considered. For storage quantities in excess of 4550 litres, water authorities allow the warning pipe to be additional to the overflow pipe.

e. Supports of the cistern carried directly by the purpose designed structure, leaving the catchment basin to be formed into an open top watertight container, with sump drainage. A single pipe should drain off any overflow water from the sump, and lead to a discharge point at ground level where any water flow would be readily noticed. If it is not possible to terminate the discharge pipe from the sump so that any discharge of water can be seen, an audible alarm should be installed to warn of overflow conditions.

f. A ball valve or other high pressure type control should be installed in accordance with Water Authority byelaws, so that it is not possible for the inlet to be submerged when the water in the tank is at overflowing level.

4.8 Combined storage/pumping systems

General

4.8.1 Where the pressure of the water undertaker's supply is inadequate, it will be necessary to achieve the required pressure by using pressurization plant. Similarly pumping or pressurization may be required for fire fighting

purposes. For buildings higher than about ten storeys it is necessary that consideration be given to pressure balancing at individual draw-off fittings either by means of orifice plates or by arranging the piping system in vertical zones with reducing valves. For very high buildings the provision of intermediate water storage and further pumping equipment may be necessary.

Pumping systems

4.8.2 Pumping systems to obtain the pressure required to distribute water to the various departments of the health building may follow one of the following methods:

a. Pumped distribution mains, the pressure in the main being sufficient to lift water via service pipes connected to it to supply cisterns located in the various buildings.

b. The supply of water to a cistern installed at low level and from which a pump or pumps deliver water to storage located at the higher levels.

c. The installation of a hydro-pneumatic system incorporating duplicate booster pumps and pressure vessel.

Arrangement of pumping system

4.8.3 The arrangements referred to above are indicated in Sheets 1–7 in Appendix 3 of this memorandum. They are self-explanatory and apart from Sheet 6 relate generally to tall buildings. In such buildings it is desirable to limit the pressure on water fittings to approximately 1·5 to 1·8 bar. Various alternative arrangements are possible to achieve this and some are indicated in Appendix 3.

a. Appendix 3 Sheet 1 shows the main storage for 24 hours on the roof, supplied by one set of duty and standby pumps. Subsidiary storage for 4 hours is situated on intermediate floors.

b. Appendix 3 Sheet 2 indicates 24 hours' storage spread between intermediate floors, each cistern to serve the distribution of a number of floors, supplied by one set of duty and standby pumps. This is generally considered to be a better arrangement than that shown in Sheet 1.

c. Appendix 3 Sheet 3 has 16 hours' storage at ground level and 8 hours' storage at roof and intermediate floors supplied by one set of duty and standby pumps.

d. Appendix 3 Sheet 4 indicates the provision of a second set of pumps to serve the upper section of the premises. This is advisable in high rise buildings as, whilst it means an increase in the number of pumps, the arrangement reduces the individual pump size and avoids excessive pressure in the lower sections of the system.

e. Appendix 3 Sheets 5 and 6 illustrate a hydro-pneumatic system. This arrangement uses a booster pumping set to provide a constant pressure (within set limits) for the water storage in an air-pressure vessel. The vessel is pressurized by air supplied from either a separate local air compressor or from a centralized system via a pressure switch. As water is drawn off the system, the compressed air expands and the pressure is reduced. The level of water in the vessel falls to the lower limit and starts up the pump, which continues to run until the high water level is reached. As shown on Sheet 5 this incorporates three pumps each capable of providing half the water quantity required against the total system head. The pumps are arranged to work in sequence. This system is the usual choice in hospitals as it provides central boosting facilities for all services including drinking water. It is more economical from the viewpoint of installation and maintenance than boosting on a similar scale with booster pumps only.

f. Appendix 3 Sheet 7 shows an alternative pressurized system with continuously running pumps with 100% duty pump and support pump on automatic pressure control, and 100% automatic standby pump. The duty pumps run continuously during the time of demand, and are controlled either manually or on a time clock. A selector switch enables the duty and standby pumps to be interchanged. The pumps must be protected from overheating during periods of no draw off, and this is simply achieved by providing a recirculation connection from the discharge main back to the break cistern. A constant flow valve may be fitted in the recirculation line so that a constant recirculation takes place irrespective of pressure. A low level cut-out device protects the pumps against low level conditions in the break cistern, which could be caused by a failure of the water supply. Care should be taken in the design of the system to ensure that the pipework does not drain down through the recirculation pipe. As water is being circulated through this break cistern, it is necessary to comply with the Model Water Byelaws 1966 which state that the mains supply to the break cistern must be through a type 'A' air gap to ensure that there is no possibility of back siphonage occurring. This will entail an over-rim supply pipe controlled by a float switch and solenoid valve and not by the conventional ball valve within the cistern.

4.9. Storage for system building (Nucleus) hospitals

In the Nucleus Hospital design provision is made for separate cold water storage cisterns as follows. Cisterns should be provided for:

a. Cold water storage (treated if required) for serving the hot water supply systems.

b. Potable cold water storage serving a common water down feed system of distribution pipework supplying all sanitary and drinking water fittings and equipment in general use within the hospital. See Appendix 3 Sheet Nos 9, 10 and 11.

Potable cold water cisterns should comply with Model Water Byelaws (1966) paragraph Nos 9, 40 and 41 and should conform to requirements listed under "Drinking Water" in Section 5.17.

5 Distribution pipework

5.1 General

5.1.1 The design of the pipework should ensure that there is no possibility of a cross connection between installations conveying potable water and an installation containing impure water, water liable to contamination or of uncertain quality, or used water of any sort. Reflux valves, non-return valves, closed or sealed stop valves cannot act as a substitute for the complete absence of connection. There should be no possibility of backflow towards the source of supply from any tank, cistern or appliance, whether by backsiphonage or otherwise. Valves cannot be relied on to prevent such backflow.

5.1.2 Distribution network should be divided into sections by the provision of isolating valves to facilitate isolation for repairs, maintenance and flushing. A stop valve should be provided near the point of connection of each service pipe. It should be located inside the building served, but dependent on byelaws and other design considerations, a further stop valve may be required outside the building.

5.1.3 When mains have been emptied for any of the reasons mentioned previously, precautions must be taken to prevent any threat of reverse flow from the site drainage or entry of vermin.

5.1.4 Air release valves should be provided at summits and washouts at low points between summits unless adequate provision is made for the discharge of air and water by the presence of service connections and fire hydrants. Where necessary air release and drainage valves should be provided so that sections of pipelines between isolating valves may be emptied and filled independently. Large-orifice air valves will discharge displaced air when mains are being charged with water. When air is liable to collect at summits under ordinary conditions of flow, small-orifice air valves, which discharge air under pressure, may be required. "Double-acting" air-valves having both large and small orifices should be provided where necessary. Air-valve chambers should be adequately drained to avoid the possibility of contamination.

5.1.5 Washouts should not discharge into a drain or sewer or into a manhole or chamber connected thereto. Where a washout discharges into a natural watercourse, the discharge should at all times be well above the highest possible water level in the watercourse. In some cases it may be necessary for the washout to discharge into a watertight sump which has to be emptied while in use by portable pumping equipment.

5.1.6 Mains need not be laid at unvarying gradients but may follow the general contour of the ground. They should, however, as far as possible, fall continuously towards the washouts and rise continuously towards the air-valves. They should not rise above the hydraulic gradient; that is to say, there should always be a positive pressure, greater than atmospheric, at every point under working conditions. The gradient between air release and drainage valves should be not less than 1:500 rising in the direction of flow and not less than 1:200 falling in the direction of flow. Long dead ends should be avoided, unless terminating at a regularly used draw-off point, otherwise stagnation might take place.

5.1.7 Underground pipes entering a building should do so at a depth of not less than 0·75 metres below the external ground surface and should pass through the wall within a watertight built-in metal sleeve. The sleeve should be filled in around the pipe with a bituminous or other suitable material for a minimum length of 152 mm at both ends to prevent the ingress of water or vermin. External underground pipes should be at a depth or otherwise sufficiently protected to prevent damage by traffic and any consequent vibrations. A minimum depth under roadways of 1 metre measured from the top of the pipe to the surface of the ground is necessary. In other underground locations the depth should not be less than 0·75 metres, subject to this depth

being sufficient protection against frost. Frost penetration depends on the nature of the subsoil and the ground surface. Freezing can occur at depths of up to 1·1 metres. Local information on the risk of frost prevalence should be sought.

5.1.8 For pipelines or sections thereof carried on supports whether above ground or buried in the ground with an inadequate load bearing capacity the number of supports will depend upon the type of joint contemplated. In such circumstances the advice of a specialist should be sought on the materials and anchorages most suitable for use in that situation. Where the installation of piping externally above ground level is unavoidable it should be insulated with waterproof insulating material and provision made for draining down the pipe in frosty weather.

5.1.9 Provision should be made at every bend, branch and dead-end in a main to resist the hydraulic thrust.

5.1.10 Pipework in buildings should be designed and installed so that it is accessible for inspection, maintenance and repair as far as is practicable. Ducts, trenches and chases containing pipework should be large enough to facilitate repairs.

5.1.11 Mains should be capable of a rate of flow to satisfy the combined maximum demand of all the services to be supplied. All the maximum demands of the separate services may not occur simultaneously, and the actual combined maximum demand may be a proportion of the sum of the separate maximum demands, which will be determined by the number and character of the services.

5.1.12 The pipeline should also be capable of withstanding the effects of any internal vacuum, pipeline empty state, and of any external loads that are likely to occur.

5.1.13 If fire protection has to be given, this will generally be found to have an overriding influence on the size of the main necessary. The rate of flow required in the main and the pressure required at the hydrants will vary according to the fire risk involved.

5.1.14 Even a slight heat gain can render a potable water unpalatable, therefore mains run above ground externally or in heated areas must be efficiently insulated and consideration given to siting to reduce heat gain from solar or mechanical effects.

5.2 Prevention of corrosion

5.2.1 The choice of materials for piping and fittings should take into account the nature of the soil in which the piping is to be laid and the character of the water to be conveyed. The materials selected should where necessary resist possible corrosion both inside and outside. The extent, if any, of anti-corrosion treatment of the outside of the piping will depend on the analysis of the soil. The advice of the water authority should be sought on the protective measures usually adopted in the area.

5.2.2 Corrosion may result from galvanic action where metals are used such as copper in contact with iron or steel or with zinc galvanised coating. The use of dissimilar metals should be avoided or they should be kept apart by the use of fittings made of electrically non-conducting materials.

5.2.3 Corrosion can also be caused by the motion of water when it is in a turbulent state and thus subject to rapid changes in pressure. Minute vapour or gas bubbles may be released at instants of low pressure which collapse with implosive force the moment the pressure is increased. The collapse of such bubbles upon metallic or concrete surface will quickly cause deep pitting or erosion of that surface. The designer should therefore avoid if at all possible high velocities, the sudden increase of pressures or pulsating pressures.

5.2.4 Metallic piping should not be installed in contact with magnesium oxychloride flooring composition as this is injurious to most metals and alloys. Similarly contact should be avoided with any quick setting material having an acid content.

5.2.5 All metallic piping should be bonded, to prevent local differential potentials, in a manner described in the Institution of Electrical Engineers Regulations, current edition.

5.3 Corrosion in relation to materials used

Iron

5.3.1 Iron has good resistance to corrosion and this is further enhanced if the casting skin on the metal is still intact. Although ductile iron pipes are thinner than grey iron pipes, their resistance to corrosion is at least as good, and there is evidence that they tend to be rather more resistant. In assessing the life expectancy of ductile iron pipelines, account should be taken of any intended higher operating pressures that may be used or permitted.

5.3.2 The internal and external coatings detailed in the relevant British Standards for grey iron should also be used for ductile iron. B.S.4622 and B.S.4772 require coatings to comply with the requirements of B.S.4164 or B.S.3416. These coatings give adequate protection in all normal circumstances and cathodic protection is not normally necessary.

5.3.3 In made ground containing ashes, clinker, refuse, industrial wastes or in certain natural soils, such as aggressive waterlogged clays, saline and peat marshes, additional external protection may be required. This may be provided either by the use of selected non-aggressive backfill material or by the use of protective coatings such as bitumen or coal tar sheathing, by protective tapes, by loose polythene sleeving or, in certain circumstances, concrete. Reference should be made to C.P.2008 for further details and recommendations.

5.3.4 Where the contents of the pipeline are conducive to tuberculation, the pipes should be concrete lined or protected by other suitable lining.

Steel

5.3.5 Where steel is used for bolts, nuts and slip-on couplings, adequate protection from corrosion should be provided. This usually takes the form of bitumen coating.

5.3.6 Unless adequately protected, steel is liable to corrosion both internally and externally, and therefore, should not be used untreated. Steel piping is usually supplied zinc galvanized, but dependent on the character of the water to be conveyed, it may be necessary to use piping with an internal coating of bitumen or with an epoxy phenolic lining which requires special application techniques. External protection for piping may consist of a bitumen or tar wrapping with reinforcing layers of fibre glass or a plastic cladding.

5.3.7 Hot dip bitumen internal and external coating can be used for 17 to 2134 mm od pipes. This treatment is only suitable for above ground installations. Bitumen linings can be used for 60 to 2134 mm od pipes. Epoxy phenolic lining can be used for 17 to 2134 mm od pipes. Glass fibre reinforced bitumen enamel wrapping can be used for 89 to 2032 mm od pipes.

5.3.8 Internal protection for larger bore steel pipe is usually supplied by hot dipping in non-toxic tar or bitumen compounds, alternatively linings of cement mortar, bitumen or coal tar pitch applied by a centrifugal process can be used. External protection for the larger bore pipe may take the form of a thick sheath of bitumen which should be continuous over the joints.

5.3.9 Where screwed steel piping is used, any threads exposed after jointing should be painted, or in the case of underground piping, thickly coated with bituminous or other suitable composition to prevent corrosion.

Lead

5.3.10 Lead piping must not be used to convey water which is plumbo-solvent. Lead piping is liable to corrosion when in contact with fresh cement, cement mortar, plaster or concrete and it should be protected either by a suitable pipe coating or it should be surrounded by a protective material when installed.

Copper

5.3.11 Copper piping and brass fittings must not be used where water conveyed is capable of dissolving an undue amount of copper or zinc in the fittings. External protection from corrosion may be obtained by providing a polythene sheath. Copper piping laid underground should conform to B.S.S.2871 Part 1.

Asbestos-cement

5.3.12 Asbestos-cement pipes generally withstand corrosion but may have to be protected when laid in soil of high sulphate content. If iron fittings are used both internal and external protection must be applied.

Plastics

5.3.13 Polythene pipes are immune to corrosive environments likely to be encountered from the water flowing through the pipes or from the ground in which they are laid. The only water service applications for which they are not recommended are in those places where the ground is liable to be contaminated with coal gas which might cause detectable tainting of water due to the aromatic constituents of the gas permeating through the polythylene walls.

Concrete

5.3.14 Protection of concrete pipes may be required against sulphate and acid attack. The minimum size available in concrete pipework is 150 mm diameter so its practical use for health buildings is very limited.

5.4 Construction of distribution pipework

5.4.1 Care should be taken in the handling or transporting of pipes to ensure that they are not subject to any sharp impacts or blows which may impair the protective coating or cause partial cracking or complete breakage of the pipe. The pipes should be stacked in accordance with the manufacturer's instructions.

5.4.2 Prior to placing in the trench the pipes should be visually inspected for evidence of damage, with particular emphasis laid on examination of the interior surface at the spigot ends. In the case of iron pipes (grey iron or ductile) a "ringing" test can be applied to a pipe suspended at its point of balance, a crack being indicated by a dull muffled note on the striking with a light hand hammer. The steel pipes will have been inspected at the manufacturer's factory prior to coatings being applied. The coatings

should be tested by the use of a Holiday detector immediately before lowering and backfilling, to detect whether or not the external bitumen wrapping has been damaged. The Holiday detector is battery operated, portable and provides a high voltage. A metal brush connected to one terminal is passed over the pipe which is connected to the earth terminal of the instrument. Defects in the pipe coating allow a small current to pass which is indicated audibly or visually on the instrument.

5.4.3 Trenches should be cut at least 300 mm (12 in) wider than the outside diameter of the pipe being laid. Additional excavation is necessary at each joint to provide sufficient room for the joint to be properly made and to ensure that the pipe rests on the barrel and not on the socket. For iron pipelines the preparation of the trench bottom to give an even bed for the barrel of the pipe and the proper alignment of the pipes are of primary importance. In rock ground the trench should be excavated at least 100 mm (4 in) deeper than required and then made up to the required level by the addition of well compacted soft granular material. Freshly mixed concrete of sufficient stiffness to support the pipe may be used instead of granular material.

5.4.4 Where a change in direction is being made by utilizing the lateral deflection available from flexible joints the trench should be cut to give sufficient room for the joint to be made with the pipes in line, the pipe being deflected after the joint has been made. Where plastic pipes are being installed underground particular care should be taken with the trench preparation, bedding and sidefilling. Reference should be made to C.P.312, Part 1 1973 in this respect.

5.5 Classes and types of pipes and fittings

5.5.1 The materials generally used for the conveyance of water in health buildings are iron, steel, copper, plastic, asbestos-cement, concrete or lead.

Iron pipes and fittings

5.5.2 Grey iron pipes and fittings should generally comply with the requirements of one of the following British Standards:

B.S.78	Cast iron spigot and socket pipes (vertically cast) and spigot and socket fittings Part 1 Pipes Part 2 Fittings
B.S.1211	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage
B.S.2035	Cast iron flanged pipes and flanged fittings
B.S.4622	Grey iron pipes and fittings
B.S.4772	Ductile iron pipes and fittings

Grey iron and ductile iron pipes are not available in sizes less than 80 mm,.

5.5.3 Metric size grey iron pipes and fittings to B.S.4622 and metric size ductile iron pipes and fittings to B.S.4772 are not interchangeable with their imperial size equivalents. Metric size grey iron pipes to B.S.4622 are interchangeable with metric ductile iron pipes to B.S.4772.

5.5.4 Spigot and socket ductile iron pipes in Imperial sizes have no British Standard Specification, for with the advent of metrication it is intended only to provide a metric standard, namely B.S.4772.

5.5.5 Ductile iron fittings are supplied for use with ductile iron pipes. Details of these fittings are given in B.S.4772. Fittings complying with the requirements of this specification are not interchangeable dimensionally with grey iron fittings to B.S.78 and B.S.2035. They do, however, follow dimensions of metric grey iron fittings specified in B.S.4622. Metric fittings in both grey and ductile iron, other than flanged fittings, are generally of the all socket type. Flange details for grey and ductile iron pipes are given in B.S.4622 and B.S.4772 respectively with an appropriate cross reference in B.S.4504.

5.5.6 Details for Imperial sizes are given in B.S.10 but this standard is becoming obsolescent and will eventually be withdrawn. Until metrication has been completed there could be a need for metric pipes and fittings to be supplied with flanges complying with the requirements of B.S.10 where it is necessary to joint up to equipment, eg valves that have B.S.10 flanges. In such cases it is necessary to specify clearly the required B.S.10 flange to be used on the metric casting. There is no interchangeability between flanges to B.S.10 and flanges to B.S.4504.

5.5.7 Ductile iron pipes and fittings possess high tensile strength, ductility and resistance to fracture impact and are thus particularly useful in hazardous areas where the ground is unstable or subject to high traffic loading or frost effects. In time, spun iron is to be phased out and this is already being done with the availability of fittings.

5.6 Joints for iron pipes

5.6.1 Joints for iron pipes are generally of a type using resilient joint rings of rubber or similar material as a sealing medium. The most commonly used types of joint are described below. The actual details may differ from one manufacturer to another.

Bolted-gland joints

5.6.2 Bolted-gland joints are made on pipes having a plain spigot at one end and a specially formed socket at the other. The spigot is entered centrally into the socket and the seal is effected by the compression of a lead-tipped rubber gasket between a seating on the inside of the socket and the external surface of the spigot. Compression is achieved by means of a pressure gland and bolts located through a circumferential flange cast integrally on the face of the socket. Such joints provide little or no restraint against spigot withdrawal due to ground movement or internal pressure and must be anchored at changes of direction and blank ends.

Bolted-gland joint (self-anchorable)

5.6.3 This is a modified form of bolted-gland joint incorporating a ductile iron circlip which is located in a chamber or groove cast in the socket and which registers with a groove specially machined in the spigot. This joint is used primarily for gas pipelines at pressures of up to 0·8 N/mm^2 (8 bar). When the circlip is fitted the joint becomes self-anchoring. This joint may be assembled without the circlip and the seal will not be affected if pipes with plain spigots are used; the joint then will not be self-anchoring. A special tool is required to dismantle the joint if the circlip has been fitted. The joint is supplied for metric size ductile iron pipes only and the components are not interchangeable with those of the bolted-gland joint.

Slip-on couplings

5.6.4 The slip-on coupling is designed for use with plain end pipes. It consists of a sleeve, at the ends of which are wedged-shaped rubber gaskets and flanges held together with bolts. Tightening of the bolts compresses the gaskets between sleeve and pipe to seal the joint. The coupling sleeve normally has an internal rib (central register) which acts as a locating stop, but sleeves without this rib are supplied to facilitate the insertion of closing lengths in a pipeline.

Push-in joints

5.6.5 Push-in joints are made on pipes having a plain spigot at one end and a specially formed socket at the other. The seal is effected by means of a rubber gasket placed within the socket before jointing. Entry of the spigot is required to complete assembly in the case of smaller pipes; tackle to joint the larger pipes is supplied by the manufacturer.

Lead-caulked joints

5.6.6 Lead-caulked joints are made on pipes having an enlarged socket at one end and a plain or beaded spigot at the other. The spigot is entered centrally into the socket of the adjacent pipe and a quantity of spun yarn compressed into the annulus until this is filled to approximately half of the socket depth. Molten lead is poured into the remaining annulus and, after cooling, is caulked using a suitable tool. Fibrous lead may be substituted for molten lead. This type of joint is normally for grey iron pipes only. The lead-caulked joint has been largely superseded by the various types of flexible joint owing to its inability to accept deflection, vibration or axial movement without leakage. The use of jute and hemp yarns has also been rejected by water authorities unless they can be adequately sterilized, as they can promote microbial growth.

Flanged joints

5.6.7 Flanged joints are made on pipes which have a machined flange at each end of the pipe. The seal is usually effected by means of a flat rubber gasket compressed between the flanges by means of bolts which also serve to connect the pipes rigidly. Gaskets of other materials, both metallic and non-metallic, are available for special applications.

5.7 Steel pipes and fittings

5.7.1 Steel pipes of small diameter (15 mm to 50 mm nominal dia) are commonly used because of their capacity to sustain high pressure and they are relatively cheap. Because of problems which might arise due to welding, galvanized pipes with screwed ends to B.S.21 taper thread connected by steel couplings are widely used. The pipes are supplied in lengths of about 9 metres which can be bent on site by means of a portable bending machine. Where the soil is of a corrosive nature the pipes must be additionally protected by means of bitumen and glass fibre cloth wrappings. The pipes should comply with B.S.1387 which stipulates three classes of steel pipe, of which only heavy grade should be laid underground.

5.7.2 Steel pipes between 60·3 and 1861 mm O/D should comply with B.S.534. In the sizes which will normally be warranted, the lack of a satisfactory means of jointing which does not interfere with the pipe lining, discourages the use of steel pipes up to 600 mm. Steel piping may be jointed by welding, except where the piping has a lining which would be damaged by heat.

5.7.3 Screwed steel piping is jointed with screwed socket joints, using fittings of wrought-iron, steel or malleable cast-iron. A jointing compound or tape, which may be one of the many proprietary makes, is used according to the makers' instructions. Compounds containing red-lead should not be used because of the danger of contamination of the water. Care should be taken to remove any burr from the ends of pipes

and to prevent the entry of excess jointing material. Steel piping may also be jointed with screwed flanges of steel or cast-iron.

5.8 Copper pipes and fittings

5.8.1 Copper pipes are obtainable in sizes between 6·6 and 159 mm O/D and straight lengths of 4 to 6 m long or in coils of longer lengths of fully annealed copper. For above ground work Table X of B.S.2871, Part 1 refers and for below ground reference should be made to Table Y of the same British Standard. Fittings should comply with the requirements of B.S.864. Screwed copper piping may be jointed with screwed alloy fittings and piping with plain ends dealt with by means of compression joints or capillary joints. Effective capillary jointing of copper pipes can only be achieved if great care is taken in its execution. A typical good specification for this procedure is given in Appendix 5. Where compression joints are used with fully annealed copper piping, these should be manipulated joints, ie joints in which the pipe ends are belled or grooved. Copper piping may also be autogenous or bronze welded.

5.9 Lead pipes

Lead pipes have now only limited use, having been generally superseded by polythene and PVC pipes which are cheaper and easier to install but offer the same advantages.

5.10 Asbestos cement pipes and fittings

Asbestos cement pipes should comply with B.S.486 and C.P.2010, Part 4. They need great care in handling due to their brittle nature and are liable to damage from shocks and vibration. Jointing may be dealt with by the use of flexible joints in which jointing rings on the pipe ends are compressed inside an enclosing sleeve. (See also 4.7.12).

5.11 Plastic pipes

5.11.1 Materials in common use are polythene types 32 (low density) and 50 (high density) the latter being stronger and more rigid than type 32. Unplasticized polyvinyl chloride (uPVC) is also used. PVC pipes to B.S.3305 and B.S.3506 are of rigid material which has a greater tensile strength than polythene. This material is less susceptible to frost damage than metal pipes but nevertheless should be buried to a minimum of 0·75 m. Although the freezing of water inside the pipe is unlikely to damage the pipe it will result in interruption of supply and subsequent leakage from joints may occur. Trouble has been experienced with pipes over 51 mm dia (2 in nominal) fixed above ground.

5.11.2 It is essential to consider the locality of exposed PVC pipes to ensure that there is no likelihood of mechanical damage, otherwise suitable protection around the pipe will be necessary. PVC piping should be adequately supported and care taken to restrain pipes where changes of direction occur.

5.11.3 Methods of jointing employed include compression joints with insert liners, flanged, screwed and fusion welded joints, as well as joints of the spigot and socket type. The method of jointing employed is dependent on the bore of the pipe and the applied internal pressure, and should be in accordance with the manufacturer's recommendations. Joints should be made by a competent fitter.

5.12 Concrete pipes

Standard concrete pipes may be used when not subjected to internal pressure. Prestressed concrete pipes are available as pressure pipes but only in larger sizes.

5.13 Valves

5.13.1 Valve bodies should be of similar material to that of the pipelines when installed in metal pipework installations. Valves should comply with the requirements of one of the British Standard specifications listed in Appendix 7.

5.13.2 A clear indication should be given on all valves of the direction of rotation needed to close the valve. The sense of rotation should be the same for any one pipe installation. Normally it is waterworks practice to have clockwise closing when looking down on the valve.

5.14 Prevention of contamination

5.14.1 Research studies by the Thames Water Authority and the National Water Council have shown that contamination of water supplies can originate from the plumbing materials used in the installation pipework conveying the water. This contamination which impairs the quality of the water usually by taste, odour or turbidity arises from the ability of some plumbing materials to support microbial growth. An increase in the number of cases of contaminated water has been noted with the expansion of the manufacture of new plumbing materials, but studies have also shown that many of the standard jointing materials used in the plumbing industry for a large number of years are capable of supporting microbial growth, in particular the growth of fungi.

5.14.2 The Model Water Byelaws contain clauses prohibiting any installation or fitting that can cause contamination. The National Water

Council Approvals Board requires that all materials and fittings for use in contact with potable water must give satisfactory results when examined by procedures developed by the Thames Water Authority. Lists of approved materials that have passed these tests are produced by the National Water Council. Future installations using materials not shown on these lists should not proceed until these materials have been submitted to the Water Authority concerned, for their approval. The Thames Water Authority have indicated that they are not prepared to approve installations with jointing compounds and materials that do not conform with their test requirements.

5.14.3 Because of the multiplicity of materials that are available, a full testing procedure programme has not yet been completely carried out, but it can be assumed that certain materials will support abundant microbial growth and their use should not be approved. They are jointing materials based upon linseed or any other vegetable oil, shellac, all grease type fluxes, tallow, animal fats and vegetable fibres including jute and hemp. Vegetable tanned leather should not be used for washers or gaskets.

5.14.4 Soft polyurethene and polysulphide jointing compounds not only support abundant growth but the polymer molecules can sometimes biodeteriorate to a stage that affects their physical properties and water impermeability.

5.14.5 Many of the plastics now being produced are not, as generally assumed, microbiologically inert. One of the worst offenders is plasticized PVC used for flexible pipes and anti-splash nozzles.

5.14.6 Preference when using fluxes should be given to the water soluble or dispersible types that will be flushed out in the initial sterilizing and commissioning stage.

5.14.7 PTFE tape and other pure PTFE products and silicone oils, greases and rubbers are usually found to be microbiologically inert, provided they do not contain any other ingredients that could support growth. Such products may be used until lists of fully approved named materials are available. PTFE dispersions or emulsions in surface active agents (detergents) are unacceptable because the surface active agent can support growth.

5.14.8 To achieve freedom from effect on water quality many synthetic materials are dependent on an adequate curing time and temperature. This is not easily achieved with materials that are mixed on site in approximate proportions and cured in situ often under cold ill-ventilated conditions.

5.14.9 The samples for testing are produced under properly controlled factory conditions and a material prepared under site conditions cannot be guaranteed to behave in the same way as the test samples.

5.14.10 The Institute of Plumbing is compiling a Jointing Applications Chart which, when published, will be the official guide and is expected to be backed by legislation. Until this guide is available the following guidance is given on current types of joints.

a. *Wiped lead and solder joints.* As there is yet no alternative to tallow, the plumber must prevent it entering the bore of the pipe or fittings.

b. *Capillary joints.* Until soluble fluxes become generally available care must be taken that the minimum flux is used to avoid any entering the tube bore.

c. *Compression fittings.* No jointing compound is required. The common practice of adding linseed oil based white pastes will be prohibited by the Water Authorities.

d. *Bronze welding and hard soldering of large diameter copper tube.* This should be done by hard soldering only, either using borax flux or fluxless brazing.

e. *Screwed galvanized fittings up to 50 mm.* Paste and hemp joints are prohibited and only PTFE tapes to be used.

f. *Screwed galvanized iron pipes over 50 mm.* As PTFE tapes do not always make a satisfactory seal on these sizes, the suitability of specialized pastes is being investigated. Until such time as identifiable products have been approved nylon or polypropylene fibre could be used in preference to jute or hemp.

g. *Screw and bolted flanges.* Asbestos, fibre or metal washers or gaskets. Linseed oil based pastes must not be added to these fittings.

h. *uPVC fittings.* Solvent cement is satisfactory for this type of jointing.

j. *Mains joints using a "push fit" system with specially designed rubber rings.* A lubricant called "Medlube" has been specially produced for this purpose by the Water Research Centre and should be used in preference to the soft soap based lubricants usually recommended by the pipe manufacturers.

k. *Cast iron socket and spigot joints.* Caulked lead joints using a jute yarn can only be used if the jute yarn has been treated with an approved biocide.

l. *Connections to taps and ball valves.* A grummet of hemp or sail twine is now prohibited and only rubber or fibre washers should be used.

m. *Connections to cisterns.* Rubber, polythene, or fibre washers are to be used without the addition of linseed oil based pastes or hemp twine. A check should be made to ensure that if a plastic cistern is to be used it is included on the National Water Council approved list.

5.15 Backsiphonage

5.15.1 In all cold water installations it is important that adequate protection is provided to all supplies against backsiphonage. Health buildings are premises where a high degree of protection should be afforded not only to the water in the statutory water undertaker's mains, but also within the installations to protect the patients and staff. In addition to protection against backsiphonage being afforded at every point of use, whole installation protection should be provided as recommended in the Department of the Environment's "Report of the Committee on Backsiphonage in Water Installations". The recommendations in this section are in accordance with the report.

5.12.2 Health buildings and medical premises have been identified as involving Class 1 risks which are defined in the report as permanent or the occasional possibility of contamination which may make the water harmful to health. Within these establishments, water usage ranges over the whole spectrum from domestic use by patients and staff, to specialized use in operating theatres and pathology laboratories and with equipment such as bed pan washers and haemodialysis machines. In addition, many users may be classed as industrial, such as centralised laundries.

5.15.3 The report states the general case under Section 1.04 thus:

> "In the general case, three conditions must be satisfied for backsiphonage to occur in an installation:
>
> a. An appliance of fitting must be connected to the installation in such a way that the water outlet is submerged or close to the water surface;
>
> b. the valve or tap controlling flow from the installation to or through the appliance or fitting must be open;
>
> c. the pressure in the pipe connected to the appliance or fitting must fall below the equivalent of that of the free water level at the fitting or appliance."

To be successful in preventing backsiphonage it is necessary to make certain that these conditions cannot occur.

5.15.4 Normally, 24 hour storage capacity is required for Health Buildings supplied by cisterns containing water at atmospheric pressure. Whole installation protection to the public water mains should be afforded by supplying water to these storage cisterns through an approved air gap. There are two forms of air gap applicable to cistern water supply.

5.15.5 A type A form of air gap is required when the water supply to the cistern is from an open-ended pipe above the cistern. This method of water inlet is used where the overflow is unrestricted (over the rim of the cistern) or where there is a recirculation of water through the storage cistern (see Appendix 3 Sheet 7). The Model Water Byelaws state that for these conditions the air gap should be not less than 6 inches but most Water Authorities will accept the report which states that the minimum type A air gap in these circumstances can be 70 mm for a 40 mm supply pipe. A general rule for larger supply pipes is for the air gap to be twice the diameter size of the supply pipe.

5.15.6 A type B form of air gap is required in the more general case of storage cisterns with ball valve control of the water level. In cisterns up to 4546 litres capacity the air gap measured vertically between inlet and water level should not be less than 45 mm. Other forms of air gap are incorporated within this minimum distance (see Appendix 3 Sheet 8). Inlets should discharge at levels higher than the overflow pipe by not less than the diameter of the pipe (distance a) which should have a minimum diameter of 32 mm. Ball valve floats should be adjusted after installation so that the highest level the water can reach is not less than 25 mm below the overflow (distance b). In cisterns over 4546 litres capacity the air gap between inlet and water level should not be less than 75 mm.

5.15.7 Diaphragm type ball valves are required to be quiet in operation and have to satisfy anti-siphonage test requirements to comply with B.S.1212 Part 2. When installed in accordance with the B.S., in cisterns from which flow is by gravity, they provide a satisfactory degree of protection. Other ball valve assemblies, particularly those to B.S.1212 Part 1 should not be permitted to have silencing pipes fitted to the discharge, as the air gap, as a form of protection against backsiphonage, will be effectively destroyed.

5.15.8 Float or probe operated solenoid valves controlling over-rim supplies with type A air gap will provide the greatest assurance of prevention of back-flow for a cistern.

5.15.9 Sub-atmospheric pressures should be prevented from occurring in the outlet distribution system from the cisterns by providing a vent pipe from immediately downstream of the associated outlet isolating stop valve to over the cistern (see Appendix 3 Sheet 10).

5.15.10 Further information on the subject is given in section 10 of the report quoted above, which specifically refers to the protection of water used in health buildings.

5.16 Fire fighting

5.16.1 An adequate supply of water for fire fighting purposes must be provided. The mains serving the health building should be designed to provide the rate of flow necessary for fire fighting if this is greater than the fiow rate required for normal hospital needs. If a meter is installed, arrangements should be made for it to be by-passed so that full flow conditions can be obtained. Pressure and flow rates for fire fighting should be agreed with the fire authority and the water authority. Some water authorities may prefer a separate metered supply for fire fighting, using a full flow meter.

5.16.2 Department of Health and Social Security Hospital Technical Memorandum No 16 gives guidance on "Fire Precautions". Guidance will also be found in "Fire Officers Committee Rules" Edition 29.

5.16.3 All water supplies systems used for fire fighting should be capable of delivering water at each hydrant outlet to satisfy the following criteria:

Running pressure—Minimum 4·1 bar
Maximum 5·2 bar
Static pressure—Maximum 6·9 bar
Minimum flow at any Riser 22·73 litres per second
Minimum flow at One Hydrant 7·38 litres per second
Minimum flow at Two Hydrants 15·15 litres per second
Minimum flow at Three Hydrants 22·73 litres per second

5.16.4 If an adequate flow and pressure supply is available from the water authority it should be agreed with that authority and the fire authority if any existing outdoor public fire hydrants outside the curtilage of the site can be recognized as being within the fire fighting planning for the site. The need for, and extent of, any outdoor hydrant system within the site should also be agreed with both these authorities. Such an outdoor hydrant system should preferably be arranged as a continuous circuit forming a ring main from which branch connections to each hydrant would be provided.

5.16.5 The hydrants must conform to fire authority requirements and therefore should be 63·5 mm ($2\frac{1}{2}$ in) bore valved outlets to take standpipes. Guidance is given by the Fire Protection Association in Fire Safety Data Sheet No FS 6007 on Hydrant Systems.

5.16.6 Provided there is an adequate flow of water available, the pressure of the supply for hydrants and dry rising mains can be augmented if necessary for premises of normal height by using mobile fire pumps. These appliances would normally be brought and used by the fire authority. Where pressurization is required for other needs of the health building, the design should incorporate plant to deal also with fire fighting needs. Dependent on the layout of the development, a pressurized ring main should be installed. See Appendix 3 Sheet 6.

5.16.7 The minimum pressure requirements at the highest sprinkler head will depend on the required density of discharge and the spacing of the sprinklers necessary for the class of hazard. This also affects the site flow rate required. See Section 2300A and 2300B of the Fire Officer's Committee Rules for Automatic Sprinkler Installations, 29th Edition and subsequent amendments, which also gives the pressure requirements.

5.16.8 Hose reels should be capable of a minimum flow at the nozzle of 0·4 litres/sec to a distance of 6 m from the nozzle when using the highest reel. The pressure required at the reel, for 30 metres of 19 mm diameter hose with a 4·8 mm diameter nozzle is 2·9 bar and for 25·4 mm diameter hose with a 6·3 mm diameter nozzle is 0·38 bar (see Appendix B1 of B.S.C.P.310: 1965).

5.16.9 Where wet risers are to be installed within buildings water should be supplied through two automatically controlled pumps, each to give a minimum pressure of 4·1 bar; one pump to be standby to the other. From the time a wet rising main is first connected to a water supply the running pressure at any hydrant should not exceed 5·2 bar. If this precaution is impracticable a warning notice should be attached to each hydrant which is at a higher pressure to indicate that the valve should be opened with care until sufficient pressure is obtained.

5.16.10 Water supplies for fire fighting purposes should be drawn from either:

a. A storage cistern of 45·5 cubic metres minimum capacity with a minimum make-up rate of 7·58 litres per second or

b. A break cistern of 11·4 cubic metres minimum capacity fed with water from two

independent supplies, each of which together with the water in the cistern will allow water to be drawn off at a rate of 22·73 litres per second for at least 40 minutes.

5.17 Drinking water

Drinking water points are normally served by a system of pipework fed either direct from the statutory water undertaker's mains or from suitably projected cisterns. Storage cisterns must conform to the following:

a. have a tightly fitting access cover bolted or screwed in position;

b. be lined or coated to preserve the potability and quality of taste of the water;

c. have its air inlet and overflow pipe fitted with suitable filters;

d. be insulated against heat where necessary;

e. be protected against freezing where necessary;

f. be supplied exclusively from a service pipe or a pump delivery pipe drawing water either from a storage cistern which likewise complies with these requirements, or, from a pump delivery pipe, drawing water exclusively from a service pipe;

g. be regularly inspected, sterilized and particularly maintained;

h. the interior of cisterns and ball valves should be easily accessible through air tight inspection and access covers. See Appendix 2, Sheet Nos. 7 and 8.

6 Pumps and pumping systems

6.1 Operational Considerations

6.1.1 The motive power for pumps and pressurization plant should have two differing sources for Emergency purposes. If the health building is to be equipped with standby electrical generators, provision should be included for power for pumps and pressurization plant, otherwise some other form of standby power arrangement should be made. Pumps installed in the health service are normally of single stage or multi-stage roto-dynamic type.

6.1.2 Factors to be considered when selecting pumps are:

a. quantity and pressure of water to be pumped;

b. the number of units required to obtain the necessary output and to provide adequate standby capacity;

c. the desirability of speed variation;

d. the degree of automatic and sequence control required;

e. the characteristics of the system both on the delivery and suction side, pumping efficiency and priming requirements;

f. the type of materials used in manufacturing the pumps relative to the chemical analysis of the water to be pumped.

6.1.3 The operation and shutdown of pumps may be controlled by various methods depending on the circumstances, such as water level float switches, pressure switches, flow switches, electrode probes or pneumatic systems. Certain services may require the pumping equipment to be energized also from the emergency electrical service as recommended in Hospital Technical Memorandum No 11 Emergency Electrical Services.

6.2 Pumping from bore holes and wells

Vertical spindle or submersible pumps are generally used to extract water from bore holes and wells. A clear height is necessary above the pump to facilitate withdrawal of the pump, delivery pipe, spindle, and in the case of submersible pump, the electric cable.

6.3 The vertical spindle pump

The pump is immersed in the water and driven by a vertical spindle connected to the driving motor located above the water level of the well or bore hole. These machines are very reliable and designed to meet continuous heavy duty running.

6.4 The submersible pump

The particular characteristic of the pump is that it is driven by an electric motor designed to run under water. Sealed motors are used for this type of assembly. The pump can be of any design—mixed flow or purely centrifugal, single or multi-stage. This unit is simple to install and takes up less of the bore-hole casing and consequently a smaller diameter casing can be used than that required for a vertical spindle pump. Submersible pumps usually cost less than the equivalent duty vertical spindle pumps but are generally less efficient although easily maintained. The electric cable serving the motor is waterproof

and is anchored to the side of the delivery pipe. The installation can terminate at ground level without the need for a pump house. A suitable valve chamber can be constructed to give access to the delivery pipe which can be routed underground.

7 Sterilization of the completed installation

7.1 General

The sterilization of any new installation for the supply of water to be used for domestic purposes is most important. The installation must not be put into use until the sterilization process is completed. Sterilization must be carried out at the altered section where alterations are undertaken to an existing installation. The sterilization process should be carried out in the presence of and approved by an appointed specialist. The local water supply undertaking will frequently carry out this service willingly for a small fee and should be the first to be approached.

7.2 Procedure

7.2.1 Before sterilization all pipework and storage cisterns should be flushed out to remove dirty water, debris etc.

7.2.2 The main storage cisterns should be filled with water and sufficient chemicals should be used to give the water a dose of 50 milligrammes of chlorine per litre of water. If ordinary "bleaching powder" is used the proportions will be 0·68 kg of powder to 4540 litres of water; the powder should be mixed with water to a creamy consistency before being added to the water in the cistern. If proprietary brands of chemical are used the proportion should be as instructed by the suppliers.

7.2.3 When the cisterns are full the valve in the mains supply (communication) pipes should be closed. Taps in each building should be opened, working progressively away from the storage cistern or cisterns serving the building until chlorinated water (as detected by odour) is delivered from each tap, which should then be closed.

7.2.4 The storage cisterns should then be topped up with water by opening the valve in the mains supply pipe. Further chlorinating reagent should be added in the recommended proportions while the cisterns are filling.

7.2.5 The storage cisterns and pipes should then remain charged for a period of not less than 3 hours, after which a test should be made for residual chlorine. If none is found the sterilization will have to be carried out again. Finally, the cisterns and pipework should be thoroughly flushed out before any water is used for domestic purposes.

7.2.6 Cases have arisen where sterilization has been completed but commissioning of the system has not immediately followed and subsequent contamination has developed. Services which have been filled with chlorinated water should remain in a charged state until final commissioning can be carried out, when a chlorine test should be made. If no residual chlorine is apparent then the process of sterilization should be repeated. If delay is foreseen, in the immediate final charging of the system for domestic use, the sterilization should be deferred until just prior to the system being put into service.

8 Commissioning and maintenance

8.1 Commissioning

Manuals published by HM Stationery Office under the series "The Commissioning of Hospital Engineering Services Hospital Technical Memorandum No 17" include check lists indicating tests to be carried out during the construction and on the completion of installations indicated in this memorandum. The particular manual required is No 12—"Commissioning Manual Hot and Cold Water Services".

The manual refers to:

A. Tests:

a. At manufacturer's works.

b. During construction.

c. On completion to ensure the design of the project has been met including access etc for maintenance to be carried out conveniently.

B. Handing over procedures include:

a. Operation and service manuals.

b. All necessary documentation including records of tests and "as fitted" drawings, to enable criteria to be established for special maintenance routines where required.

8.2 Maintenance

Estate Management (Building, Engineering and Grounds) Practices Code for the NHS (ESTMANCODE) Chapter II, Section 2 and the associated maintenance manuals, Electrical (PMG/12) and Mechanical (PMG/13), give guidance on the implementation of routines for the maintenance of engineering plant. The routines indicated are considered to be essential requirements towards ensuring continuing efficiency in the commissioning and hand-over of installations to health authorities.

9 Water tariff

9.1 When an application is to be made to a statutory water undertaker for a supply of water to a site it will usually include a request for information of tariffs for:

a. Normal domestic purposes.

b. Commercial processes, ie laundry.

c. Fire.

9.2 Normally the supply will be requisitioned under the terms of Section 37 of the Water Act 1945, as amended by the Housing Act 1949 (Section 46) and the Water Act 1973 (Section 11b). The Regional Health Authority will be required to enter into an agreement whereby the Regional Health Authority will guarantee to make good, as a lump sum or for a period of up to 12 years, any shortfall in the income from charges levied by the statutory water undertaker.

9.3 The shortfall is that figure which represents the difference between the cost to the statutory water undertaker of laying the main to the site (excluding service pipe and metering) and the revenue which would be payable to the statutory water undertaker on the basis of water rate multiplied by the rateable value of the establishment, per annum over 12 years.

9.4 Water for fire fighting purposes is not usually metered, but the statutory water undertaker will stipulate a fixed charge based on the number of fire hydrants, hose reels and sprinkler heads which are to be fed from the fire main.

9.5 An allowance for this charge should be set against the shortfall, by the statutory water undertaker. Similarly the statutory water undertaker should make an allowance against the shortfall for water consumed by the builder during the process of building the establishment. Other arrangements such as for garden and farm watering, laundry processing etc, might qualify for an allowance to be set against the shortfall, as might also a notable and justifiable increase in metered domestic consumption. The prospect of such allowances being made and the amount will depend on the content of the project and the policy of the statutory water undertaker.

9.6 The shortfall is payable as a lump sum (a deposit would probably not be acceptable) or may be defrayed at one-eighth of the amount per annum over a period of 12 years or less depending on the changes that may take place in rateable values etc. It is therefore necessary to assess the financial involvement and decide which of the methods of payment would be the most advantageous in relation to the total funds available each year for the project.

Appendix 1

Water consumption for ward units

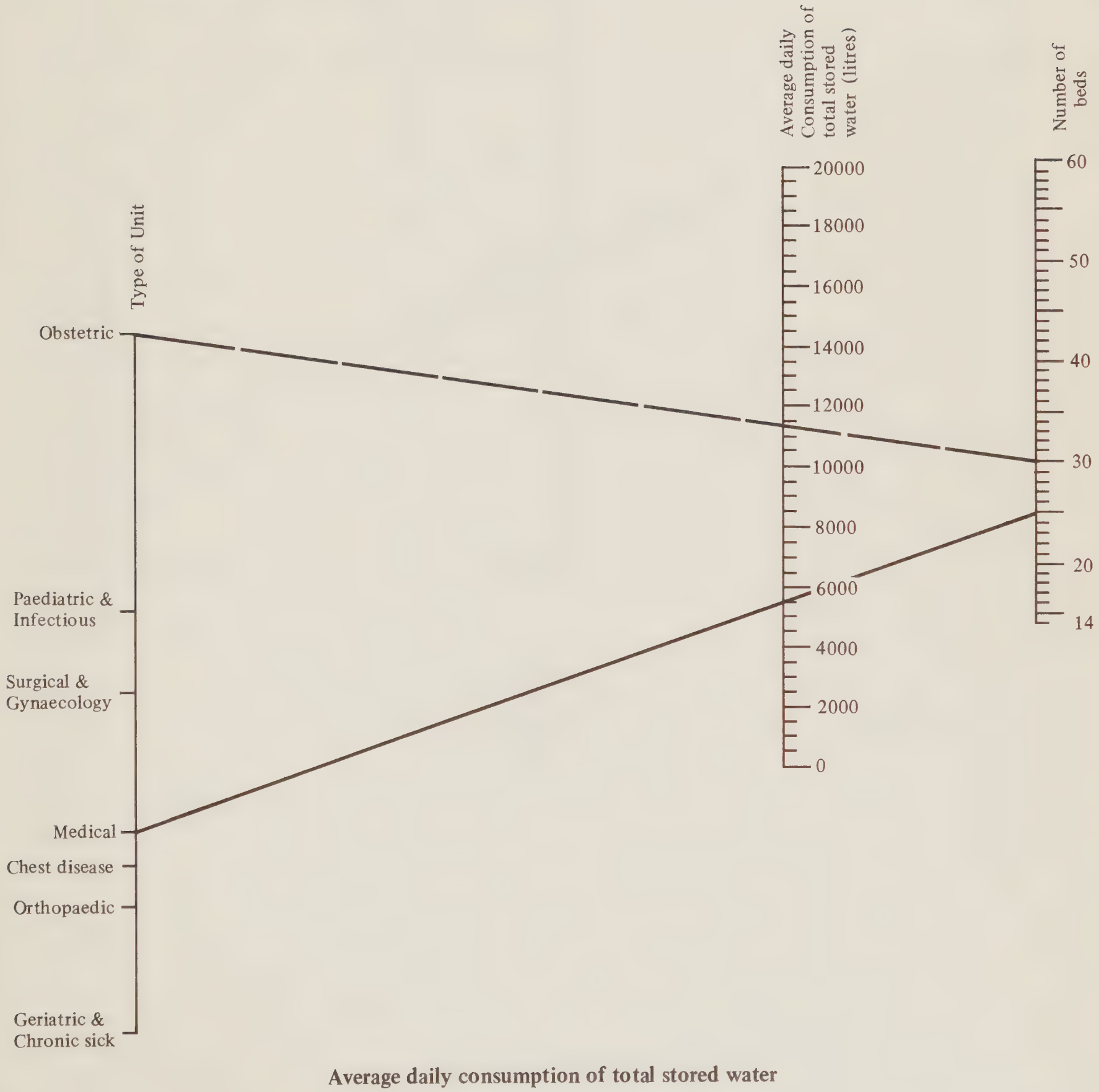
Ward Unit
All rooms which make up the working area for patient care i.e. patients' bedrooms, day spaces, treatment, utility and test rooms, bathrooms, showers and WCs, pantry, staff rooms, cleaners' room, etc. and circulation spaces.

Use of Nomogram
Project line from type of unit to number of beds. The intersection on the 20000 scale gives average daily consumption of total stored water in litres. This figure also applies to the storage capacity required for an average 24 hour supply. The result obtained relates to one ward unit. For a given number of ward units multiply by the number.

Example

5450 litres

11250 litres



Average daily consumption of total stored water

Appendix 1 (continued)

Water consumption for ward units

Use of Nomogram
Project line from point ⊕ to number of beds. The intersection on 8000 scale gives rate of supply of mains water in litres/hour. The result obtained relates to one ward unit. For a given number of ward units multiply by the number.

Example

4800 litres/h

5060 litres/h

Rate of supply of mains water to cistern

Appendix 1 (continued)

Average water consumption by type and size of hospital

The following tabulated results of a survey of National Health Service Hospitals by the Department of Health and Social Security in 1974 provides basic data for design guidance on the estimation of water storage and consumption for whole hospitals.

The definitions which have been used for the classification of hospitals are as below. "Excluded departments" are those for psychiatry (mental illness), psychiatry (mental handicap) diseases of the chest, chronic sick, geriatrics and convalescence (including rehabilitation, but not pre-convalescence).

Type of Hospital	*Type number*	*Definition*
Acute	1	Hospitals with not more than 15 per cent of their beds allocated to the "excluded departments".
Mainly Acute	2	Hospitals with more than 15 per cent and up to 40 per cent of their beds allocated to the "excluded departments".
Partly Acute	3	Hospitals with more than 40 per cent and up to 60 per cent of their beds allocated to the "excluded departments".
Mainly Long-Stay	4	Hospitals with more than 60 per cent and up to 85 per cent of their beds allocated to the "excluded departments".
Long-Stay	5	Hospitals with more than 85 per cent of their beds allocated to the "excluded departments".
Pre-convalescent	7	Hospitals with 90 per cent or more of their beds allocated to patients who have already received elsewhere the most intensive part of their treatment, but who still require active nursing care and medical oversight.
Convalescent	8	Hospitals with 90 per cent or more of their beds allocated to patients recovering from a disability who no longer require active medical supervision or nursing care in bed though they may need such simple nursing procedures as renewal of dressings or the administration of medicines.
Rehabilitation	9	Hospitals with 90 per cent or more of their beds allocated to patients who no longer require nursing care in bed and who, with or without the aid of appliances, can get about and attend to their own needs with occasional assistance but who require remedial and re-educative treatment with a view to their attaining the maximum degree of recovery of use of functions.
Maternity	11	Hospitals (including General Practice Maternity Hospitals) with 90 per cent or more of their beds allocated to obstetrics.
Psychiatric (Mental Illness)	12	Hospitals with 90 per cent or more of their beds allocated to mental disorder and 50 per cent or more of the psychiatric beds allocated to mental illness.
Psychiatric (Mental Handicap)	13	Hospitals with 90 per cent or more of their beds allocated to mental disorder and more than 50 per cent of psychiatric beds allocated to handicapped and/or severely handicapped patients.
Orthopaedic	14	Hospitals with 90 per cent or more of their beds allocated to traumatic and orthopaedic surgery, including bone and joint tuberculosis.
Tuberculosis and Chest	15	Hospitals with 90 per cent or more of their beds allocated to tuberculosis (both repiratory and non-respiratory) or diseases of the chest (including thoracic surgery) or both.
Tuberculosis and Chest and Isolation	16	Hospitals with 90 per cent or more of their beds allocated to tuberculosis (both respiratory and non-respiratory) or diseases of the chest (including thoracic surgery) or both, and infectious diseases.
Children's (Acute)	17	Hospitals with 90 per cent or more of their beds allocated as in Type 1 but for children only.
Eye	18	Hospitals with 90 per cent or more of their beds allocated to that one function.
Other hospitals	19	These include Dental and E.N.T. hospitals and also:— All hospitals with 90 per cent or more of their beds allocated to a single department not specifically named above unless that department is "General Medicine", "General Surgery" or "General Practice (Medical)" in which event the hospital would be classified as "Acute" (Type 1). Type 19 will include Geriatric and Chronic Sick Hospitals.

Appendix 1 (continued)

Average water consumption by type and size of hospital

Size band (no. of beds)	*No. of hospitals in sample*	*Total no. of beds in sample*	*Average size of hospital (no. of beds)*	*Total consumption m^3 per annum*	*Average consumption Litres/Bed/Day*
Acute (Types 1, 2, 3 and 17)					
0–50	150	4,208	28	458,900	299
51–100	58	4,151	72	602,909	398
101–200	70	9,946	142	1,780,700	490
201–400	62	18,167	293	3,914,351	590
401–600	23	10,741	467	2,348,682	599
Over 600	3	2,023	674	721,887	978
Specialist acute (Types 11, 14, 15, 16 and 18)					
0–25	53	931	18	108,336	319
26–50	18	651	36	82,455	347
51–100	38	2,664	70	352,133	362
101–200	16	1,952	122	341,004	479
Over 200	7	1,633	233	316,874	531
Long stay (Types 4 and 5)					
0–50	30	1,126	38	74,009	180
51–100	45	3,463	77	339,791	269
101–200	44	6,222	141	560,731	247
201–300	10	2,300	230	182,617	217
Over 300	3	1,121	374	125,247	306
Recovery and convalescent (Types 7, 8 and 9)					
0–25	6	126	21	9,965	216
26–50	35	1,339	38	100,721	206
51–100	19	1,357	71	91,947	185
Over 100	3	449	150	29,663	181
Geriatric and chronic sick (Type 19)					
0–50	18	573	32	51,520	246
51–100	20	1,460	73	108,163	203
101–200	6	788	131	46,987	164
Over 200	2	512	256	23,748	127
Psychiatric (Types 12 and 13)					
0–100	46	2,186	48	166,588	209
101–200	12	1,773	148	156,814	242
201–400	13	3,782	291	376,559	273
401–600	10	4,884	488	443,662	249
601–1000	7	5,112	730	654,024	350
Over 1000	5	6,098	1,220	747,676	336
London teaching (All Types)					
0–100	20	1,161	58	789,422	680
101–200	15	1,896	126	1,642,106	866
201–300	10	2,580	258	2,141,166	830
301–500	8	3,161	395	2,859,434	904
Over 500	4	2,611	652	3,207,658	1,228

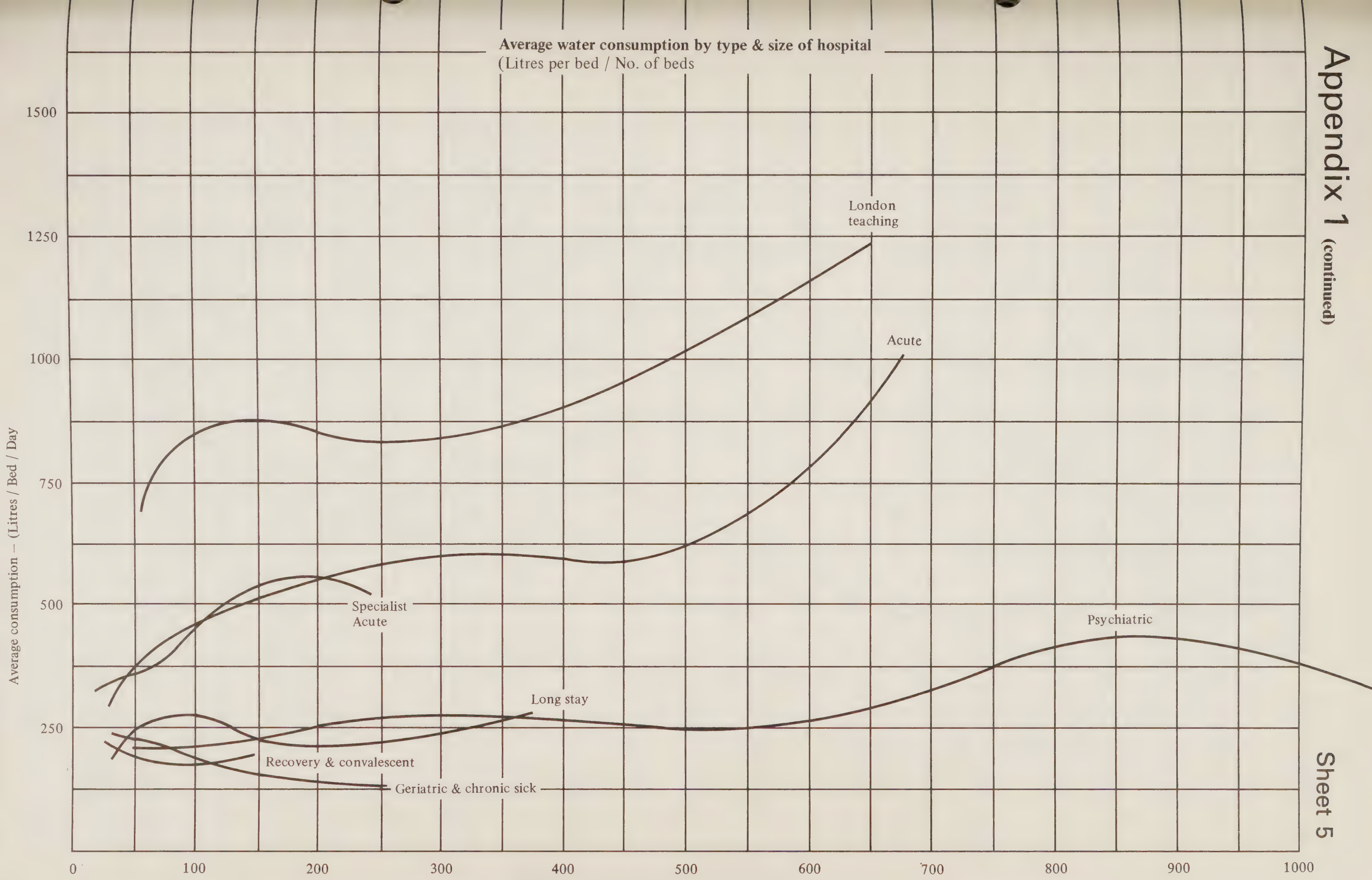
Relative-intensity of water consumption

Whilst water consumption per bed content is a convenient estimating and planning yardstick, it does not show the widely differing floor areas which are provided per bed in hospitals of different sizes and type.

To illustrate the relative rates of consumption, as seen against a basis of comparable patient density and showing the amount of water consumed, not only directly by the patient but also in the supporting treatment departments, the following graphical presentation of the preceding figures are complemented by a graph of the same consumption figures presented on a floor area basis.

Appendix 1 (continued)

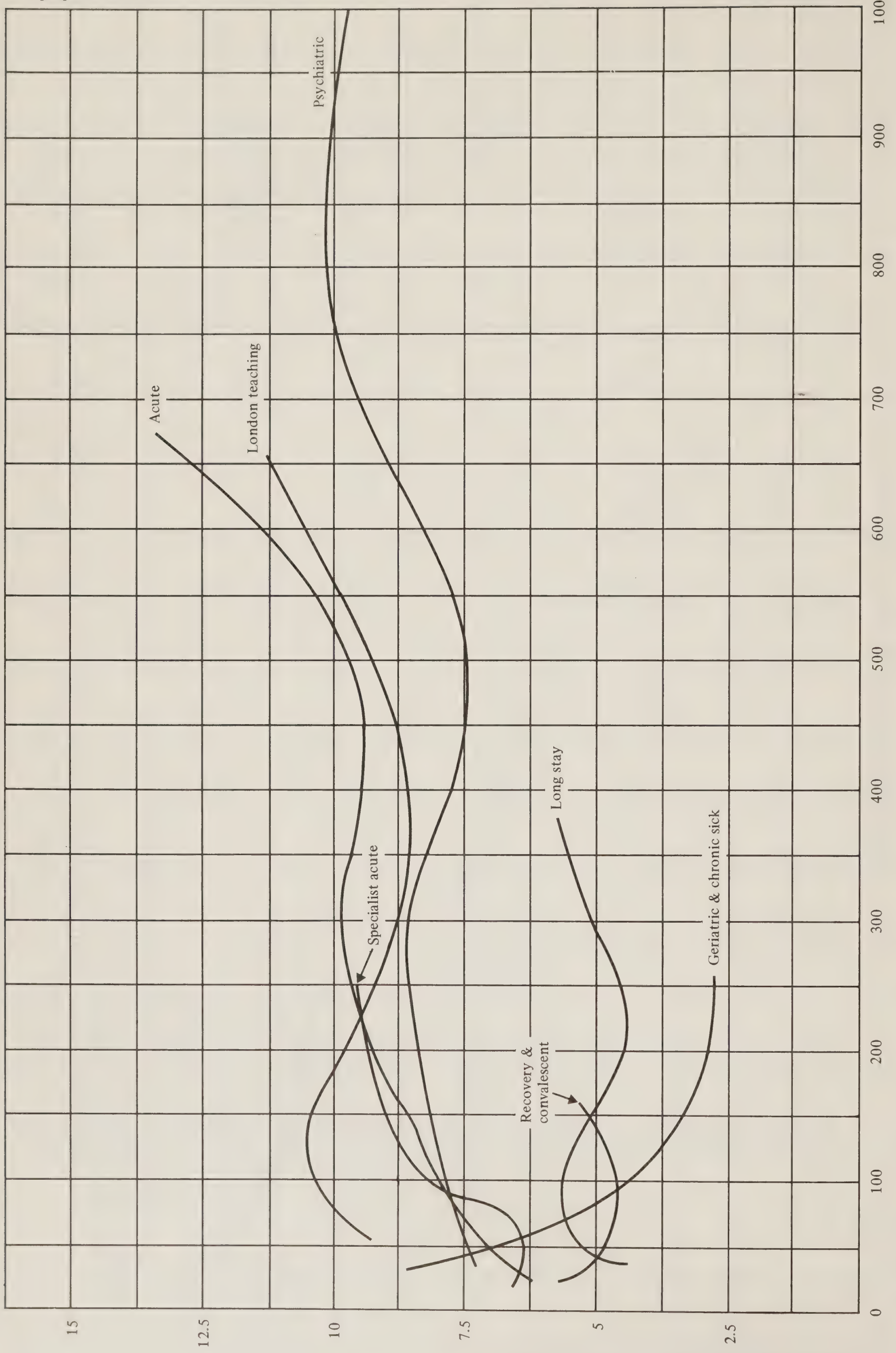
Average water consumption by type & size of hospital
(Litres per bed / No. of beds



Sheet 5

Sheet 6

Average water consumption by type & size of hospital
(Litres per m^2 floor area) / No. of beds



Appendix 1 (continued)

Residential Accommodation for Nursing Staff			
1. Data			
Type of accommodation	*Number of residents*	*Allocation of fittings*	*Total fittings*
A Student nurses	150	1 LB per person 1 Bath, 1 WC, 1 Sink } Per 5 persons 1 Laundry per 50 persons	150 LBS 30 Baths 30 WCs 30 Sinks 3 Laundries
B Staff nurses	50	1 LB per person 1 Bath, 1 WC, 1 Sink } Per 4 persons	50 LBs 12 Baths 12 WCs 12 Sinks
C–F Deputy matrons MOs etc	50 Plus 50 family residents	1 LB, 1 Bath, 1 WC, 1 Sink } Per flat	50 LBs 50 Baths 50 WCs 50 Sinks
Totals	300	—	250 LBs 92 Baths 92 WCs 92 Sinks 3 Laundries

2. Daily usage per fitting

Type of Fitting	*Accommodation A*	*Accommodation B*	*Accommodation C–F*
LB	3	3	6
Bath	$2\frac{1}{2}$	2	1
WC	20	16	8
Sink	5	4	6
Washing machine	8	—	—

3. Consumption per use

LB	4·5 litres	Sink	9 litres
Bath	72 litres	Washing machine	114 litres
WC	9 litres		

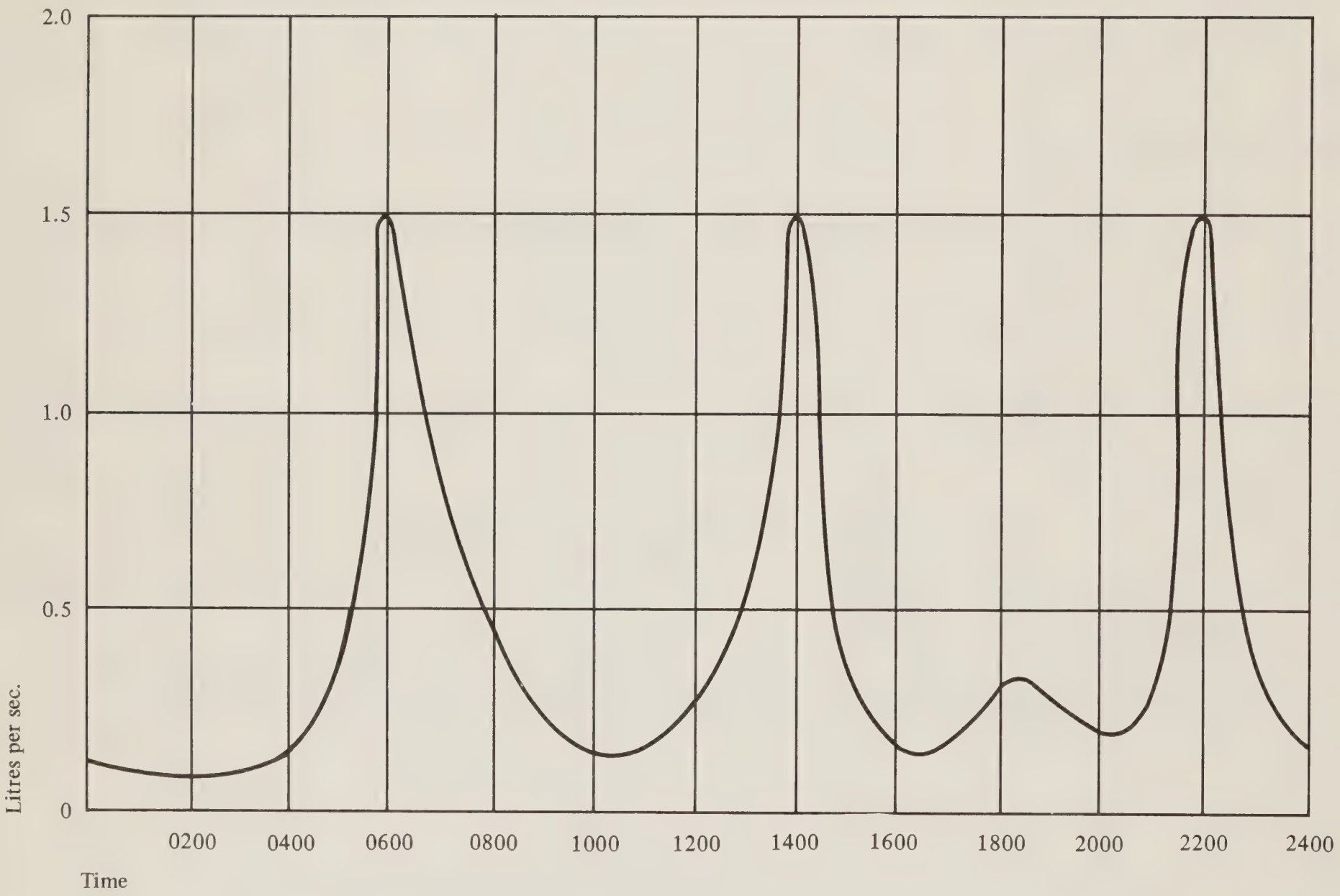
4. Estimated daily consumption = 34090 litres
   Daily consumption per person = 114 litres
5. Peak demands—

If two thirds of resident staff work three shifts commencing at 06.00, 14.00 and 22.00 hours peak demands will occur from 05.00 –07.00, 13.00–15.00 and 21.00–23.00 hours. Peak demand may reach 1·5 litres per sec with an average demand of 1·06 litres per sec over three periods

Appendix 1 (continued)

Water consumption for residential accommodation of nursing staff

Total storage = 34100 Litres
Ratio = 114 Litres / person



Demand incidence for 200 nursing staff & 100 senior staff flats (see sheet 7)

Appendix 2

Water plant

Cold water pumping sets

1.1 ***General***

Cold water pumping sets as shown on Sheet 2 are used for lifting water to a high level in buildings where there is a low level reservoir or where the mains pressure is inadequate.

Continuously running pumps are used to supply a pressurized system. Pumping sets must not be connected to the water mains supply system without the permission of the Water Authority. Normally, an adequately sized break cistern will be required to supply booster pumps if the mains pressure is inadequate. It is possible that the pressure of mains water will be adequate for part of the time in which case a by-pass arrangement may be incorporated so that the pumps can be shut down during this period.

Where the water may be used for drinking, the necessary safeguards shall be taken to avoid contamination.

1.2 ***Consumption and sizing***

A guide to the daily consumption of cold water is given in Appendix 1. Sheets 3 and 4. The capacity for lifting pumps should be calculated on the average demand over the storage period and the capacity of the high level cisterns.

Provision shall be made for the installation of a water flow meter and other instruments (eg pressure gauges etc). A drain-down valve should be fitted in a suitable position over the drainage trench.

The sizing and number of pumps will vary with the method of distribution, whether they are to be used for lifting or pressure boosting and the configuration of the health building. The pumping sets normally used are:

a. Two identical pumping units each capable of 100% duty, with one running and one as standby when the requirement is for lifting water to storage located at a higher level. Sheet 2 illustrates a typical layout of this type.

b. Three pumps each capable of providing 50% of quantity required against a total system head using a hydro-pneumatic system of control. The two duty pumps run in sequence automatically controlled with the third as stand-by. This system provides central boosting facilities from low level storage cisterns. See Appendix 3 Sheets 5 and 6.

c. Three pumps each capable of 100% duty, one as lead pump, one as support pump and one as standby. This arrangement will be required for pressurised systems with continuously running pumps. See Appendix 3 Sheet 7.

1.3 ***Electrical equipment and controls***

The pumping sets for lifting to higher level storage should be controlled from the level in the high level tanks by transmitting electrodes, level-switches or other suitable devices. A low level alarm should be arranged to give a warning when the storage volume of water falls to a predetermined low level.

The electrical control circuit should make provision for either pump to run individually or together in parallel.

All electrical equipment should be earthed.

1.4 ***Plant room***

The plant room should be constructed with a waterproof and non-dusting type of floor with a slight fall to a drainage trench which should terminate in a trapped gully. The room will require adequate lighting, ventilation and heating (to prevent freezing or condensation) with electric power points and/or provision for low voltage supplies for portable lighting and tools.

A lifting beam has not been shown on the drawing as it is assumed that portable lifting equipment will be used.

A coloured line diagram of the system, with clear working instructions shall be suitably displayed on the wall.

The projected floor area for a two pump set with pipework, valves and working clearances as shown on Sheet 2 will be about 3 m × 1·3 m.

1.5 ***Noise***

Noise generated by centrifugal pumps need not cause serious trouble, providing the water velocity in the pipes and the speed of the pumps are kept low, eg about 1 m/s and 16 rev/s (960 rpm) respectively.

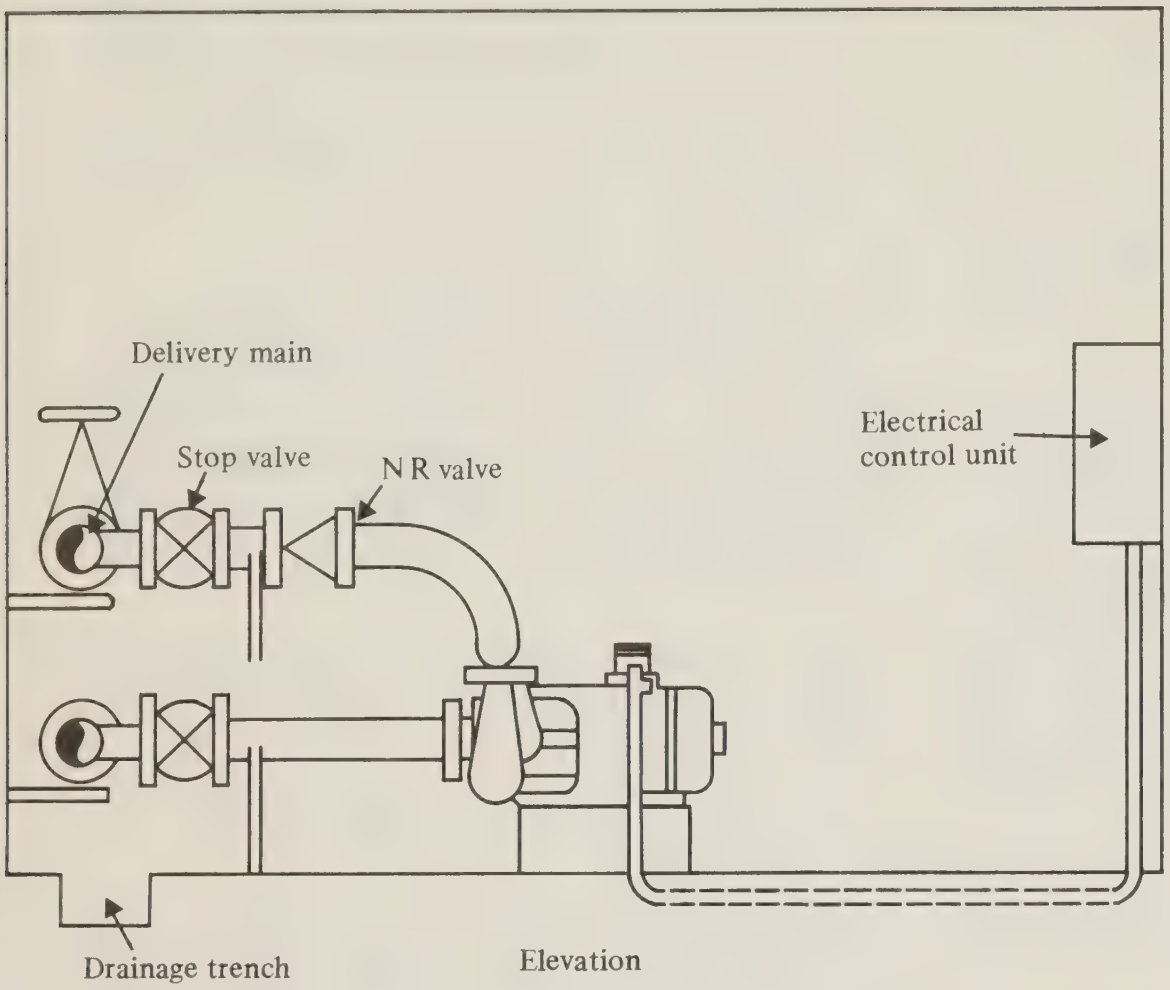
The pumps should be sited away from wards and quiet zones of health buildings, particularly automatically controlled pumps, when starting and stopping is likely to be frequent.

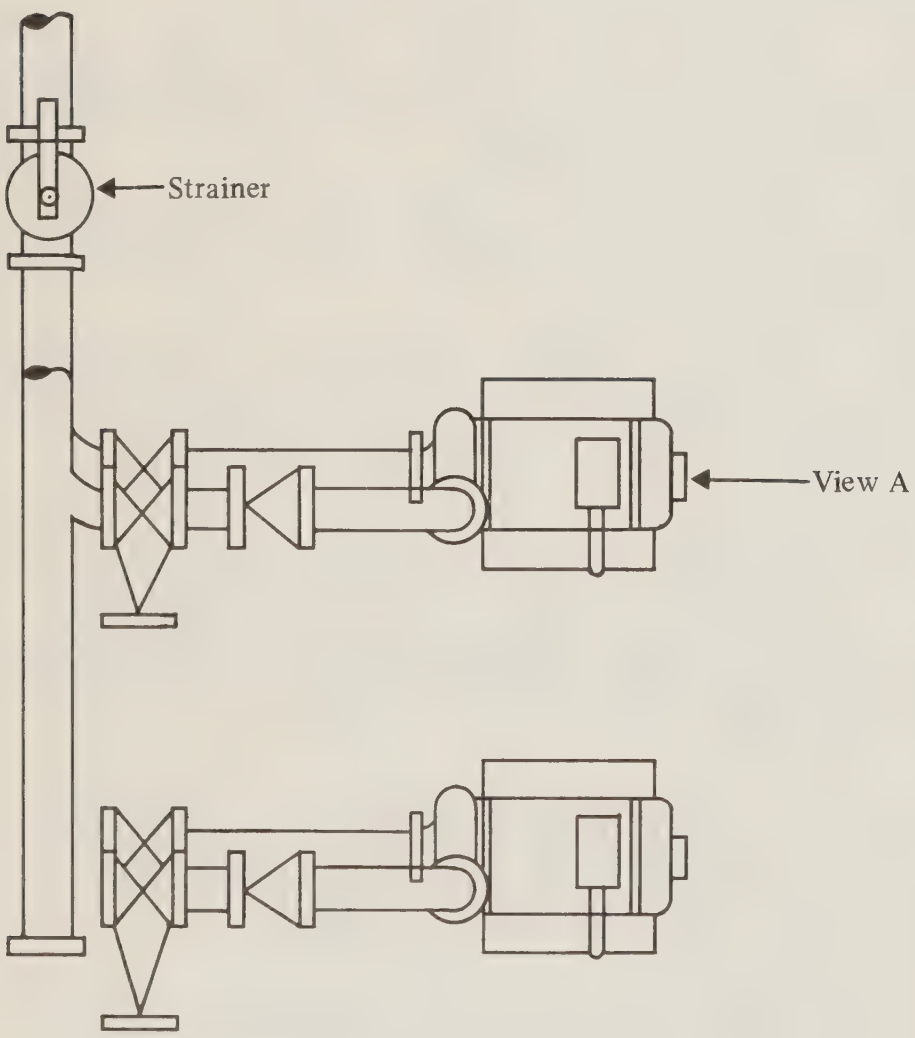
Protection against the transmission of noise through the structure and the pipework should be considered, appropriate to the location and the size of the plant.

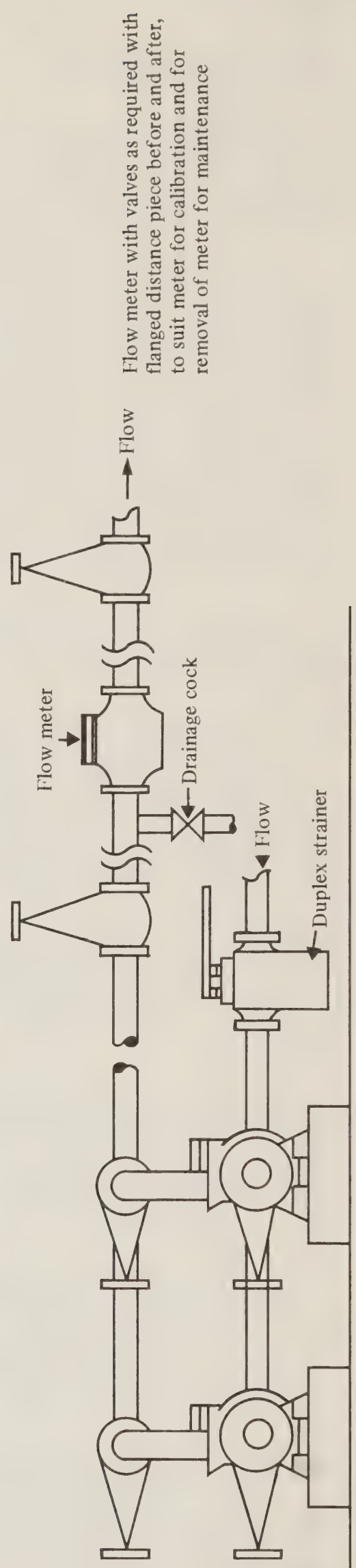
Sound from a continuously generating source is reverberated from the boundaries with the

Appendix 2 (continued)

Water Plant






Flow meter with valves as required with flanged distance piece before and after, to suit meter for calibration and for removal of meter for maintenance
Flow
Flow meter
Drainage cock
Flow
Duplex strainer
Side elevation A

Arrangement of pumping units
(see appendix 2 sheet 1 for information on connection to mains supply system)

resultant build up of sound. Consideration should be given to sound proofing where the siting and noise level make it necessary.

Cold water cisterns and cistern rooms—typical layouts

Item	Description	Sheet
1.	Types and functions of cisterns to be accommodated	3
1.1	Introduction	
1.2	Function of storage	
1.3	Types of cistern	
2.	Shape and arrangement of cisterns and cistern rooms	4
2.1	Factors affecting cistern room shapes	
2.2	Factors affecting cistern shape and arrangement	
2.3	Evaluation of cistern room layout	
3.	Valve provision and arrangements	
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4.	Pipework	
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6.	Construction of cisterns	
7.	Interchangeability	
8.	Cistern room environment	
9.	Identification	

Cistern layouts and sizes

Cistern room—Typical arrangement	6
Cistern room—Grouped valve arrangements	7
Cistern room—Scattered valve arrangements	8
Cistern room—Overflow and drain arrangements	9
Typical sizes, weights and capacities of cisterns	10
Typical sizes, weights and capacities of cisterns	11

1 Types and functions of cisterns to be accommodated

1.1 *Introduction*

Water is stored in large developments, like health buildings, for three basic reasons:

a. to provide reserve supply during failure of the main cold water supply to the development
b. to reduce the maximum demand on the cold water main
c. to provide accommodation for the expansion of any water subjected to heat, ie hot water and heating services.

It is more convenient and more secure to house such storage at sufficient height to provide adequate flow to all parts of the development by gravity, thus avoiding reliance on pumps etc. Health buildings generally provide this requirement by housing cistern rooms at roof level although wide spread building layouts sometimes require a special cistern tower.

1.2 *Function of storage*

The purpose for which the storage is used can vary, but this has only a minor effect on its design. The range of uses is generally covered by the following:

a. cold water services, domestic, laundry etc.
b. cold water feed to hot water services
c. treated cold water for laundries, heating etc when local supplies are unsuitable
d. feed and expansion for heating service
e. fire fighting

The Pathology Department will have its own storage cistern fed from but not in the main cistern room. Its function is to provide an air break to prevent backsiphonage. See Appendix 3 Sheet 10.

It is found generally that a. and e. if both are required, would be housed in a common cistern and the same would apply to b. and c. Therefore, most cistern rooms would comprise, one cold water cistern, one cistern for cold feed to hot water service and one feed and expansion cistern for the heating services. Cisterns may be subdivided in order to provide for maintenance and cleaning.

1.3 *Types of cistern*

Normally the materials used for storage cisterns in health buildings are concrete, steel and cast iron. The decision as to which is used is mainly a question of size. There is usually a practical limit to the size of welded cistern that can be used, mainly because of access during installation and handling problems. The sectional cistern usually becomes the better proposition, both economically and as regards future extension, if "in situ" welding is involved when a welded cistern has to be provided.

One piece moulded PVC or glass reinforced plastic cisterns are now becoming more common. In most instances, to give the most efficient use of space, tanks are rectangular in shape. One company has introduced a modular system for providing any required capacity. In this system a

moulded glass reinforced plastic cistern of 1136 litres capacity and shaped in the form of a hexagonal prism forms the basic unit. Multiples of this unit when interlocked at the ends or sides provide the desired total storage with provision for extension at any future date.

2 Shape and arrangement of cisterns and cistern rooms

2.1 *Factors affecting cistern room shapes*

Roof-top cistern rooms although generally rectangular in shape are variable as regards the ratio of height to length to breadth. These are usually controlled by the aesthetic aspect which will also often determine the location of the cistern room in relation to the main structure.

A further influencing factor is the load carrying capacity of the main structure. This will sometimes limit the distributed load that the cistern room and its contents will be allowed to impose on the main structure and will in turn limit the depth of water and hence the depth of cistern. If, however, cisterns can be located above main service ducts or stair wells this will minimize the effects.

There may be occasions when the main building shape will not lend itelf to a simple rectangular cistern room. These occasions will be very few and even then the overall shape constitutes a series of rectangles ie a "T" shaped or "L" shaped room. It appears quite reasonable, therefore, to base any thoughts of standard layout on a single rectangular cistern room.

Standard cistern capacities and corresponding sizes are given on Sheets 10 and 11. For alternative capacities and sizes the appropriate British Standard Publications should be consulted.

2.2 *Factors affecting cistern shape and arrangement*

Ideally one would aim for a square cistern as this would prove the most economical in respect of material costs and also in the use of space. It is more usual for the designer to fit his cistern into a given space having previously specified the total area he will require.

A further difficulty in deciding cistern shape and layout is the location of the services duct serving the cistern room in relation to the cistern area. Whereas the cistern room, as mentioned in section 2.1, may be positioned in relation to the main building from an aesthetic aspect, the duct serving it may be positioned to suit the internal layout of the main building. The services duct in relation to the cistern area, can, therefore, have a number of possibilities, the basic ones are shown on Sheet 6.

2.3 *Evaluation of cistern room layout*

As mentioned in section 2.1 the maximum permissible depth of cistern will be generally determined by the load carrying capacity of the main building or the maximum permissible height of the cistern room. The most convenient way of providing room for future expansion would be to choose an initial cistern depth of some 20% less than the maximum permissible. Extension vertically at some later date could then be carried out quite simply.

Once the initial depth of cistern has been finalised and the required storage capacity determined, the total plan area of the cistern can be evaluated. The problem now becomes one of determining the most economical cistern shape and layout to provide the best utilization of space, whilst allowing adequate space for access for maintenance and erection, space for pipe runs, valves etc. Typical arrangements are illustrated in Sheet 6.

3 Valve provision and arrangement

3.1 *Grouped arrangement*

Sheet 7 shows a proposed group arrangement of valves, for cistern rooms. The advantages gained from this arrangement are a central control and operation area which if required can be especially illuminated.

3.2 *Scattered arrangements*

Sheet 8 shows an alternative arrangement of valves giving the designer greater flexibility in layout with economical use of pipework. It would also enable the valves to be mounted close to the cisterns and reduce the possibility of losing the cistern contents through jointing failure.

4 Pipework

The arrangement of the cisterns in the room should be such that the pipework runs will be as short as possible, but ensure accessibility and walkway clearance. Flanges on parallel runs should be staggered and the pipe supports fixed to the cisterns where possible.

Adequate allowance should be made in the pipework layout for possible future cistern development.

It is recommended that provision for total flow meters should be included in the main outlet flows with appropriate by-pass arrangements as required.

5 Layout of cistern rooms

All cisterns must be contained in a catchment basin suitably water repellant lined. The basin floor should be sloped to an open drain connected to the main rain water down pipe. The drain after leaving the catchment basin should be provided with tell-tale tundish to indicate when overflow or leaks are occurring.

Each cistern should be accessible from all sides with a minimum clearance of 1 m between cistern and wall and between adjacent cisterns. A minimum clearance of 1 m should be provided above the cisterns to allow access for inspection, maintenance etc.

The layout should provide for a utilization factor of between 40% and 45% of the total floor area available in the cistern room. This is excluding pipework runs.

Cistern support levels should be constructed to keep the valves clear of the water level in the catchment basin in the event of a cistern rupture. A minimum of 0·5 m should be provided between the floor of the catchment basin and the under side of the cistern.

The cistern supports should transmit the loads direct to the main structural floor beams and not via the catchment basin. It is recommended that the layout of the cistern supports should be closely co-ordinated with the architect and structural engineer.

Suitable power points for low voltage small tools and inspection lamps should be provided.

It is recommended that a branch tee with valve and hose connections be provided at some convenient point in the water inlet to provide cistern washdown facilities.

6 Construction of cisterns

Cisterns should be fully closed and constructed to the appropriate British Standard where applicable. The cisterns should include all necessary flanged connections for inflow and outflow, vent, drain and overflow, also hinged manhole covers and visible ball valve inspection covers. Air filters should be fitted on vents and overflows.

It is suggeted that liquid level pressure pads be provided with remote indicators and alarms in the main pumphouse.

If the cistern room is located in an exposed position it may be necessary to insulate the cisterns and in some cases provide means for maintaining the water temperature above freezing.

7 Interchangeability

Interchangeability between the cold water cistern and the hot water service cistern can be arranged by providing a pipework connection between the cold water supply and the hot water services supply. This connection should have an isolating valve which is normally closed. See Sheets 7 and 8.

8 Cistern room environment

General space lighting should be provided supplemented by portable hand lamps. Pilot indication should be relayed to the pumphouse or any such similarly frequented area.

Space heating it not considered necessary as heat gained from transfer losses from lower floors is usually sufficient to maintain reasonable working temperature.

Ventilation by means of louvred doors is considered sufficient on roof top cistern rooms.

9 Identification

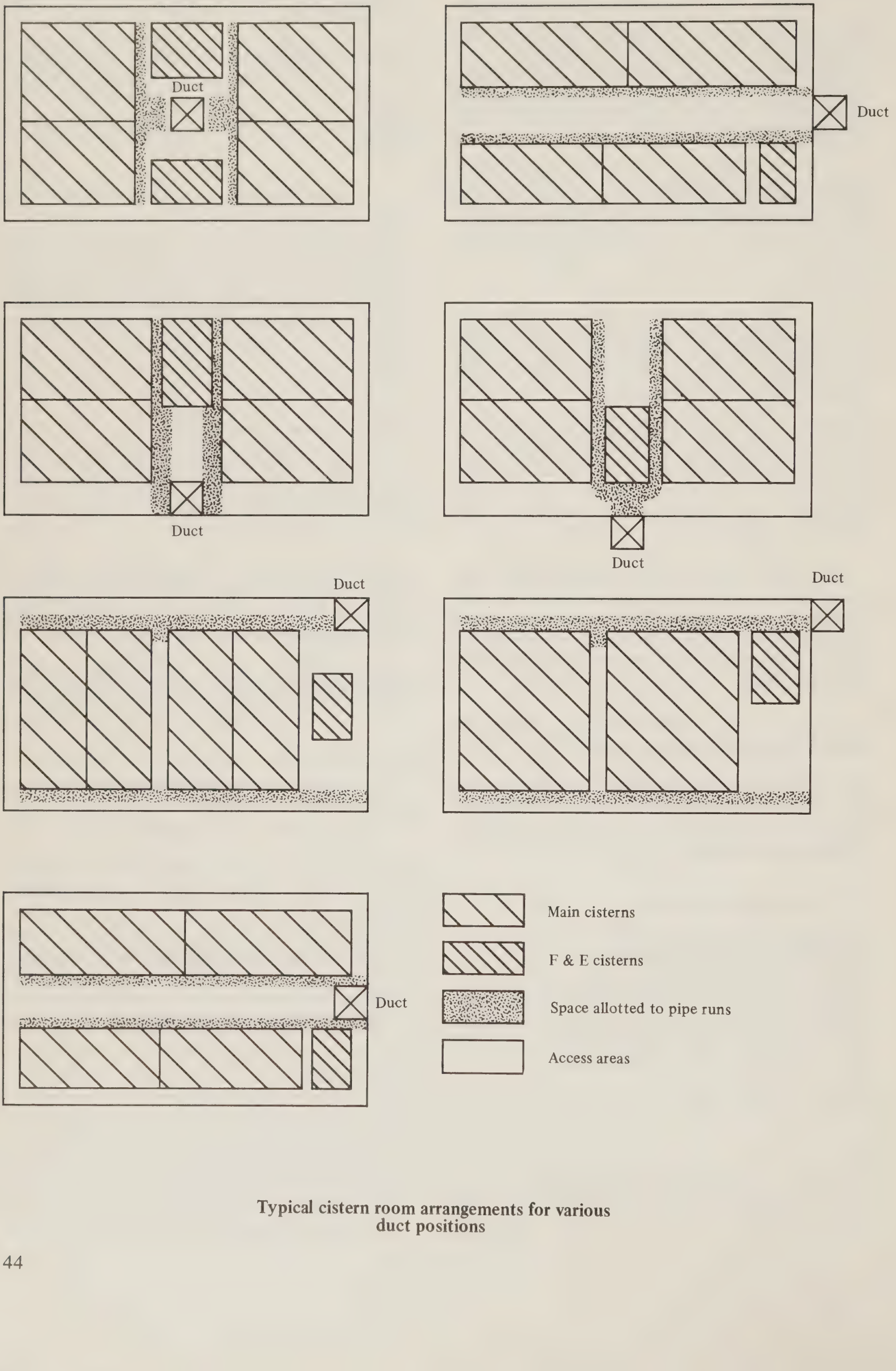
All cisterns should be clearly labelled as to contents and capacity in letters not less than 100 mm high on white background.

All pipework should be painted as required by B.S. 1710 with arrows in black on white indicating flow direction.

A glass framed coloured diagram showing the arrangement of cisterns and associated pipework must be wall mounted in a prominent position preferably with its own illumination.

Appendix 2 (continued)

Water Plant

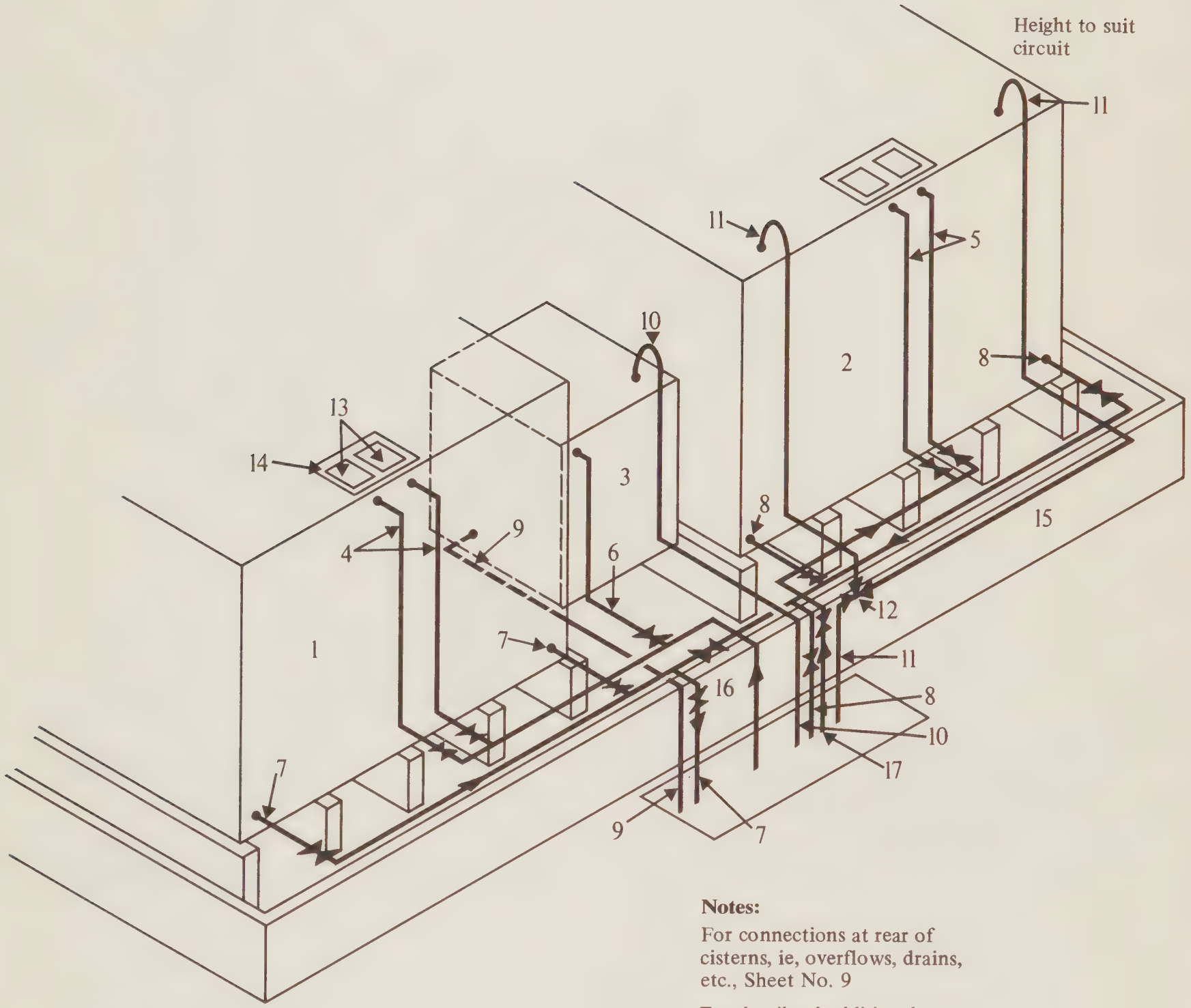


Typical cistern room arrangements for various duct positions

Appendix 2 (continued)

Water Plant

1 C.W. cistern
2 C.F. cistern to H.W.S.
3 F&E cistern to HTG.
4 C.W. main to C.W. cistern
5 C.W. main to H.W.S. C.F. cistern
6 C.W. main to HTG. F&E cistern
7 C.W. supply distribution
8 Cold feed to H.W.S.
9 Cold feed to HTG. system
10 Open vent – HTG.
11 Open vents – H.W.S.
12 Vents to cistern selector cock
13 Small valve inspection lid
14 Main access cover
15 Catchment wall
16 Primary C.W. main supply
17 Softened (if reqd.) C.W. feed to H.W.S. cisterns



Notes:

For connections at rear of cisterns, ie, overflows, drains, etc., Sheet No. 9

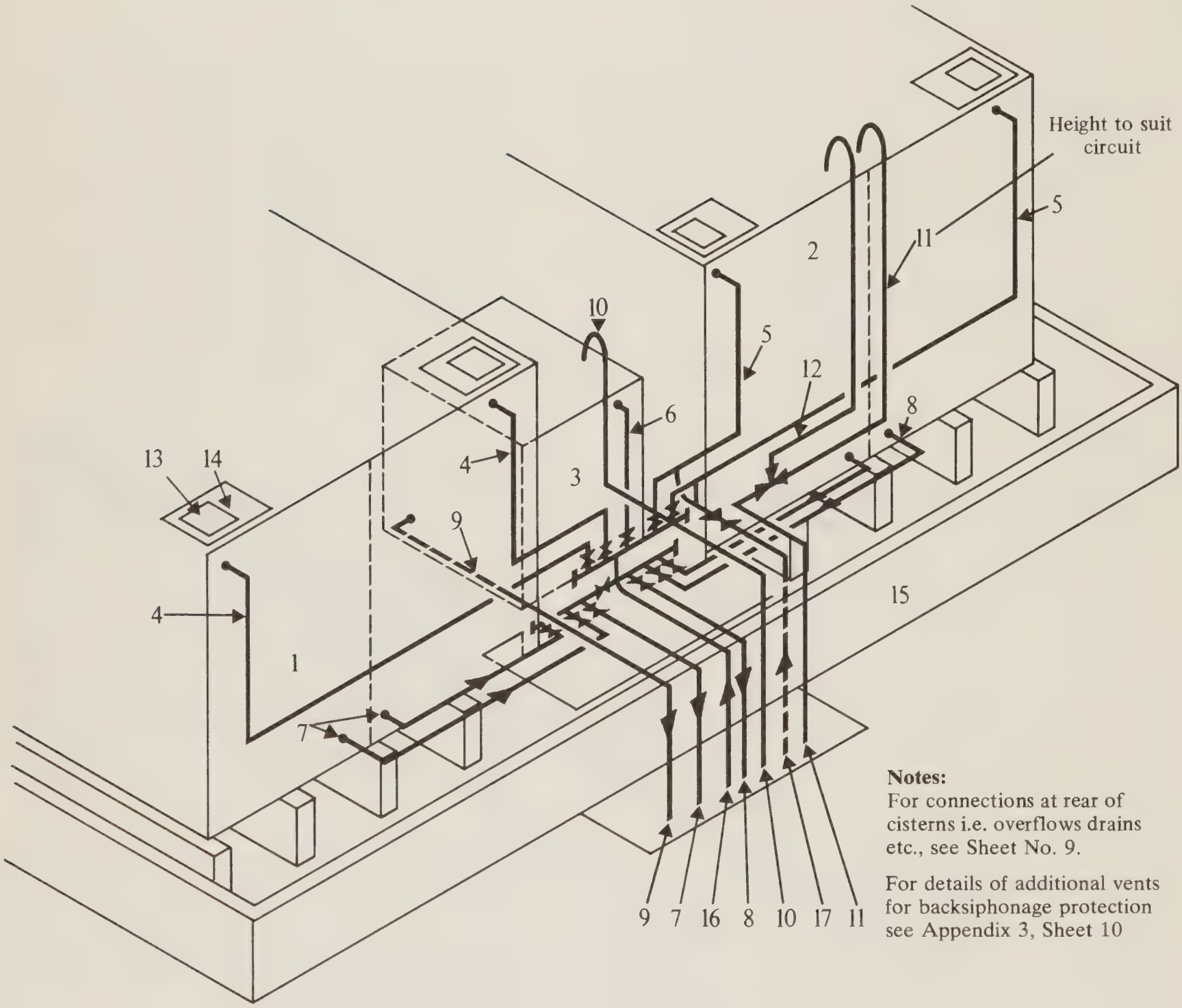
For details of additional vents for backsiphonage protection see Appendix 3, Sheet 10

Cistern room scattered valve arrangement

Appendix 2 (continued)

Water plant

1 C.W. cistern
2 C.F. cistern to H.W.S.
3 F&E cistern to HTG.
4 C.W. main to C.W. cistern
5 C.W. main to H.W.S. cistern
6 C.W. main to HTG. F&E cistern
7 C.W. supply distribution
8 Cold feed to H.W.S.
9 Cold feed to HTG. system
10 Open vents – HTG.
11 Open vents – H.W.S.
12 Vent to cistern selector cock
13 Ball valve inspection lid
14 Main access cover
15 Catchment wall
16 Primary C.W. main supply
17 Softened (if reqd.) C.W. feed to H.W.S. cistern



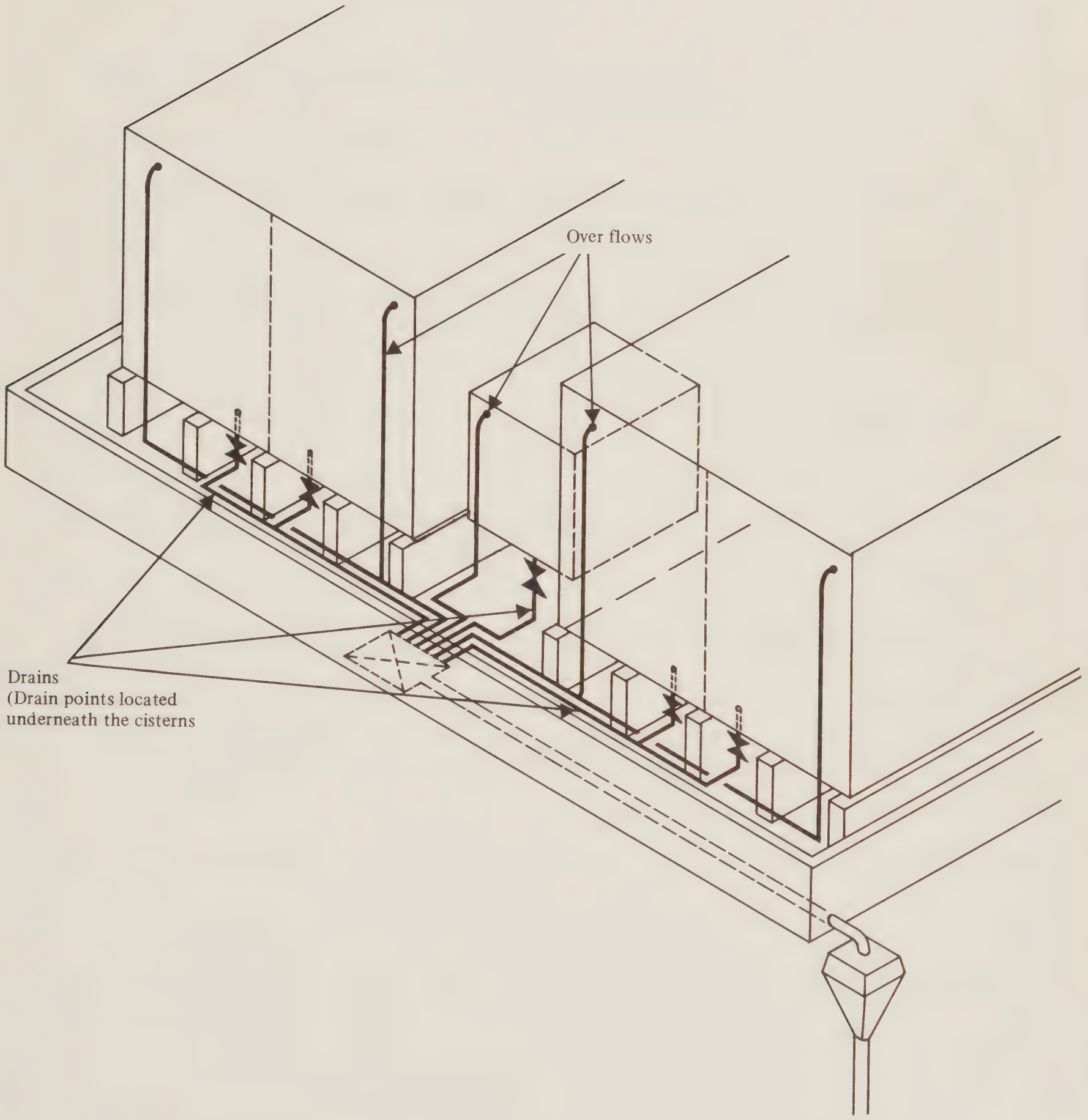
Notes:
For connections at rear of cisterns i.e. overflows drains etc., see Sheet No. 9.

For details of additional vents for backsiphonage protection see Appendix 3, Sheet 10

Cistern room grouped valve arrangement

Appendix 2 (continued)

Water plant



Overflows and drain points

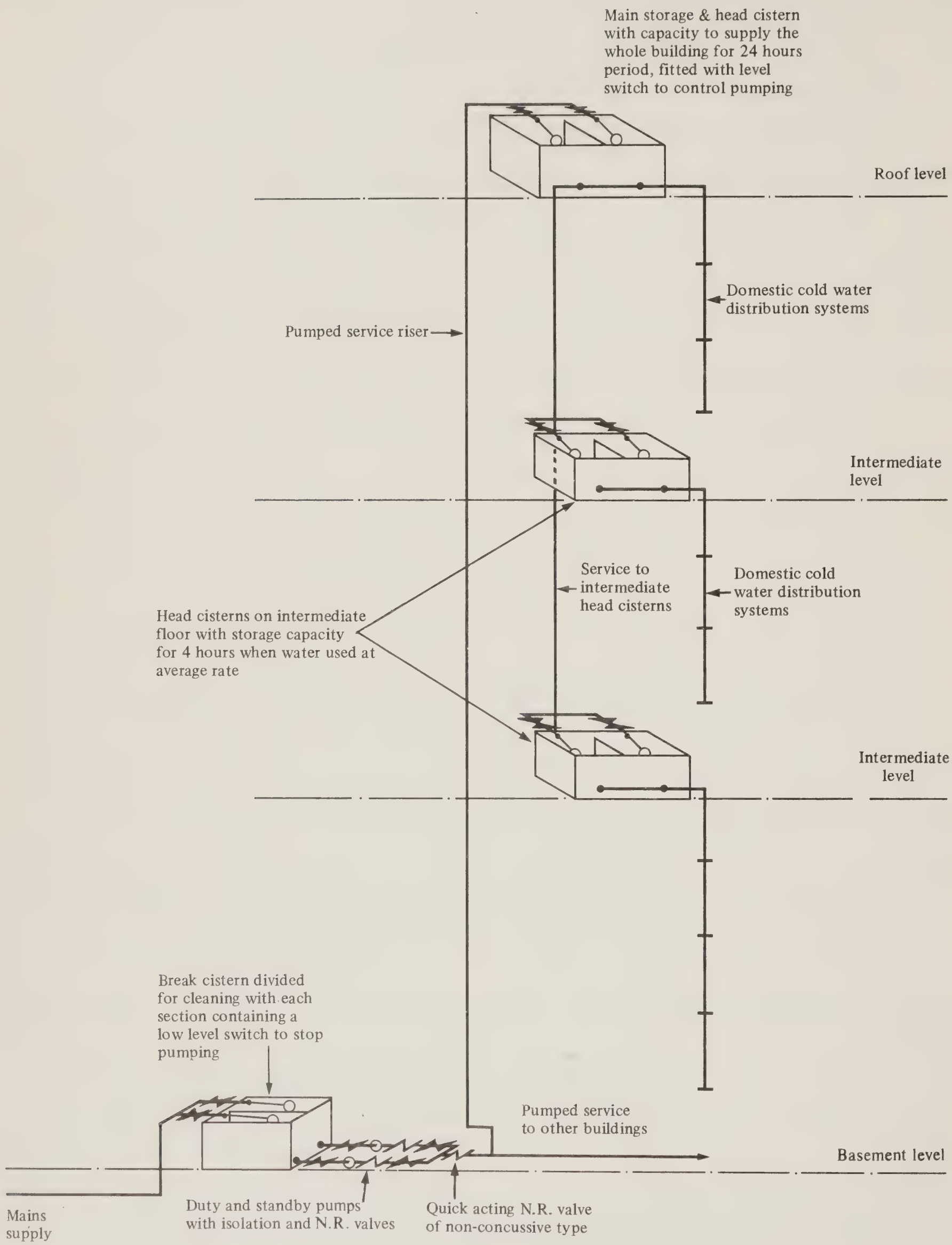
Appendix 2 (continued)

Nominal cistern size		Plates in cistern	Nominal capacity		Approx. total weight empty		Approximate outside dimensions					
Length by Breadth							Length		Breadth		Depth	
metres	feet	number	litres	gallons	kg	cwt	metres	ft ins	metres	ft ins	metres	ft ins
1·2 × 1·2	4 × 4	5	1820	400	400	8	1·35	4 6	1·35	4 6	1·3	4 3
2·4 × 1·2	8 × 4	8	3640	800	650	13	2·55	8 6	1·35	4 6	1·3	4 3
3·6 × 1·2	12 × 4	11	5460	1200	850	17	3·75	12 6	1·35	4 6	1·3	4 3
2·4 × 2·4	8 × 8	12	7280	1600	950	19	2·55	8 6	2·55	8 6	1·3	4 3
3·6 × 2·4	12 × 8	16	10920	2400	1250	25	3·75	12 6	2·55	8 6	1·3	4 3
4·8 × 2·4	16 × 8	20	14560	3200	1550	31	4·95	16 6	2·55	8 6	1·3	4 3
6·0 × 2·4	20 × 8	24	18200	4000	1900	38	6·15	20 6	2·55	8 6	1·3	4 3
3·6 × 3·6	12 × 12	21	16380	3600	1650	33	3·75	12 6	3·75	12 6	1·3	4 3
4·8 × 3·6	16 × 12	26	21840	4800	2050	41	4·95	16 6	3·75	12 6	1·3	4 3
6·0 × 3·6	20 × 12	31	27300	6000	2450	49	6·15	20 6	3·75	12 6	1·3	4 3
7·2 × 3·6	24 × 12	36	32760	7200	2850	57	7·35	24 6	3·75	12 6	1·3	4 3
8·4 × 3·6	28 × 12	41	38220	8400	3300	66	8·45	28 6	3·75	12 6	1·3	4 3
4·8 × 4·8	16 × 16	32	29120	6400	2550	51	4·95	16 6	4·95	16 6	1·3	4 3
6·0 × 4·8	20 × 16	38	36400	8000	3000	60	6·15	20 6	4·95	16 6	1·3	4 3
7·2 × 4·8	24 × 16	44	43680	9600	3450	69	7·35	24 6	4·95	16 6	1·3	4 3
8·4 × 4·8	28 × 16	50	50960	11200	4000	80	8·55	28 6	4·95	16 6	1·3	4 3
9·6 × 4·8	32 × 16	56	58240	12800	4600	92	9·75	32 6	4·95	16 6	1·3	4 3
6·0 × 6·0	20 × 20	45	45500	10000	3550	71	6·15	20 6	6·15	20 6	1·3	4 3
7·2 × 6·0	24 × 20	52	46410	12000	4100	82	7·35	24 6	6·15	20 6	1·3	4 3
7·2 × 7·2	24 × 24	60	57330	14400	4650	93	7·35	24 6	7·35	24 6	1·3	4 3
8·4 × 8·4	28 × 28	77	61880	19600	6050	121	8·55	28 6	8·55	28 6	1·3	4 3

Typical sizes, weights and capacities of cisterns with external flanges. Cisterns 1·2 m (4 ft) deep, plates 4·5 mm (3/16 in) thick.
Note 1 Approximate total weights include plates, stays, cleats, nuts, washers and jointing material.
Note 2 Nominal capacities are WITHOUT allowance for freeboard.

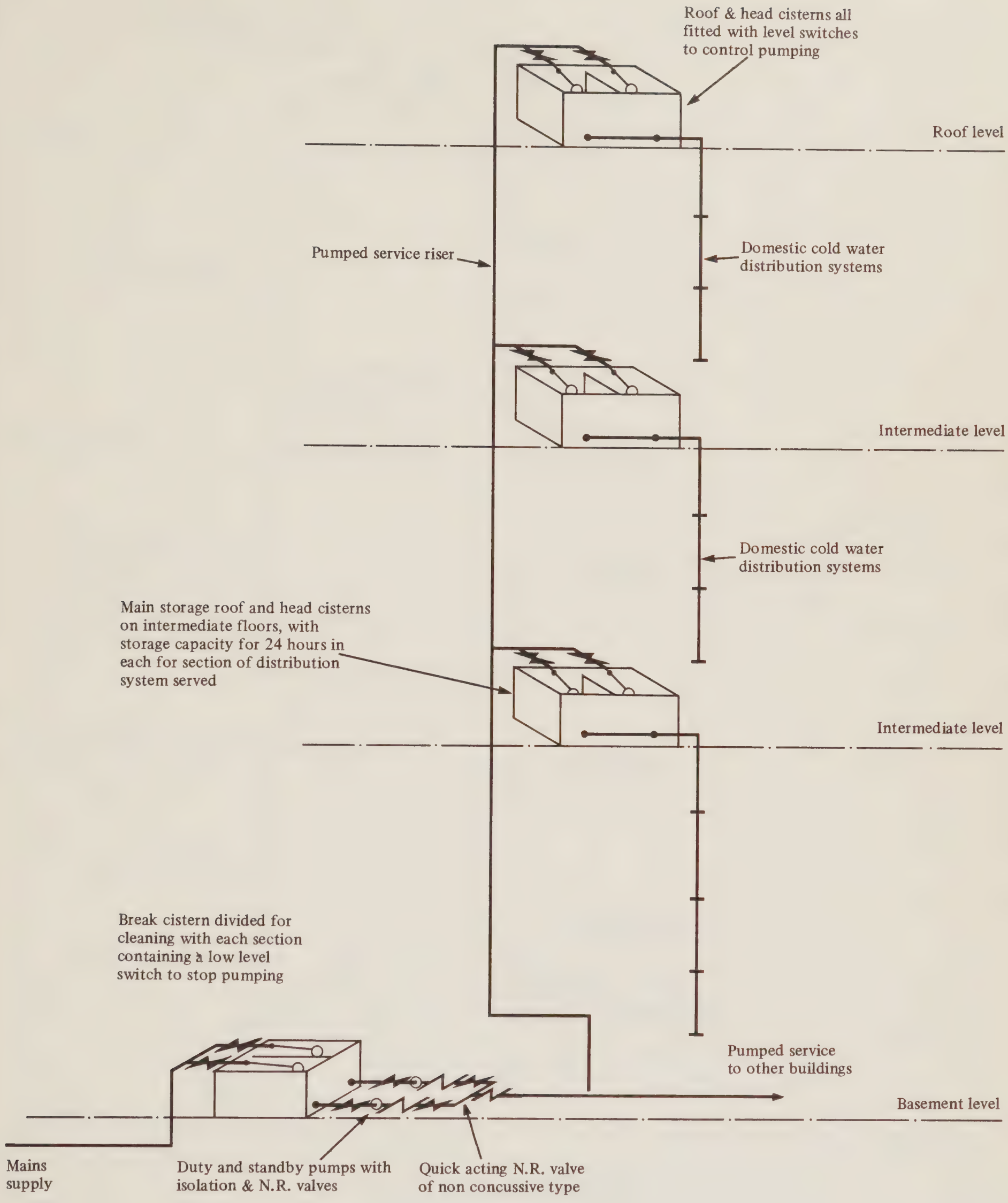
Nominal cistern size		Plates in cistern	Nominal capacity		Approx. Total weight empty		Approximate outside dimensions					
Length by Breadth							Length		Breadth		Depth	
metres	feet	number	litres	gallons	kg	cwt	metres	ft ins	metres	ft ins	metres	ft ins
2·4 × 1·2	8 × 4	14	7280	1600	1300	26	2·55	8 6	1·35	4 6	2·4	8 3
3·6 × 1·2	12 × 4	19	10900	2400	1800	36	3·75	12 6	1·35	4 6	2·5	8 3
4·8 × 1·2	16 × 4	24	14560	3200	2300	46	4·95	16 6	1·35	4 6	2·5	8 3
2·4 × 2·4	8 × 8	20	14560	3200	1900	38	2·55	8 6	2·55	8 6	2·5	8 3
3·6 × 2·4	12 × 8	26	21840	4800	2500	50	3·75	12 6	2·55	8 6	2·5	8 3
4·8 × 2·4	16 × 8	32	29120	6400	3100	62	4·95	16 6	2·55	8 6	2·5	8 3
6·0 × 2·4	20 × 8	38	36400	8000	3650	73	6·15	20 6	2·55	8 6	2·5	8 3
3·6 × 3·6	12 × 12	33	31120	7200	3150	63	3·75	12 6	3·75	12 6	2·5	8 3
4·8 × 3·6	16 × 12	40	43680	9600	3850	77	4·95	16 6	3·75	12 6	2·5	8 3
6·0 × 3·6	20 × 12	47	54600	12000	4550	91	6·15	20 6	3·75	12 6	2·5	8 3
7·2 × 3·6	24 × 12	54	65520	14400	5200	104	7·35	24 6	3·75	12 6	2·5	8 3
8·4 × 3·6	28 × 12	61	76440	16800	5900	118	8·55	28 6	3·75	12 6	2·5	8 3
4·8 × 4·8	16 × 16	48	58240	12800	4650	93	4·95	16 6	4·95	16 6	2·5	8 3
6·0 × 4·8	20 × 16	56	72800	16000	5450	109	6·15	20 6	4·95	16 6	2·5	8 3
7·2 × 4·8	24 × 16	64	87360	19200	6300	126	7·35	24 6	4·95	16 6	2·5	8 3
8·4 × 4·8	28 × 16	72	101920	22400	7100	142	8·55	28 6	4·95	16 6	2·5	8 3
9·6 × 4·8	32 × 16	80	116480	25600	7950	159	9·75	32 6	4·95	16 6	2·5	8 3
6·0 × 6·0	20 × 20	65	91000	20000	6450	129	6·15	20 6	6·15	20 6	2·5	8 3
7·2 × 6·0	24 × 20	74	109200	24000	7200	144	7·35	24 6	6·15	20 6	2·5	8 3
7·2 × 7·2	24 × 24	84	131040	28800	8400	166	7·35	24 6	7·35	24 6	2·5	8 3
8·4 × 8·4	28 × 28	105	188360	39200	10300	206	8·55	28 6	8·55	28 6	2·5	8 3

Typical sizes, weights and capacities of cisterns with external flanges. Cisterns 2·4 m (8 ft) deep plates 4·5 mm (3/16 in) and 6 mm (1/4 in) thick.
Note 1 Approximate total weights include plates, stays, cleats, nuts, washers and jointing material.
Note 2 Nominal capacities are WITHOUT allowance for freeboard.

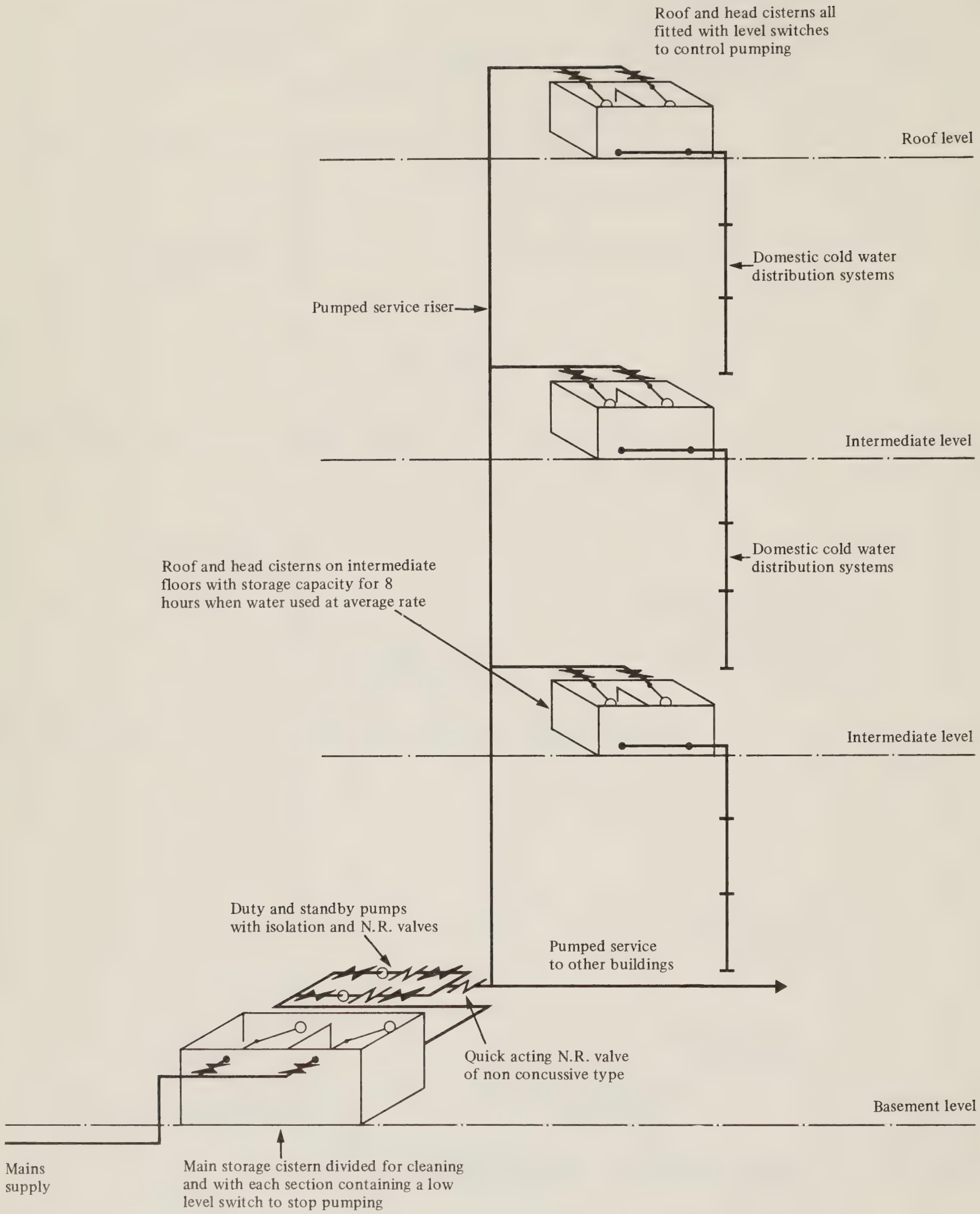

Main storage & head cistern with capacity to supply the whole building for 24 hours period, fitted with level switch to control pumping
Roof level
Domestic cold water distribution systems
Pumped service riser
Intermediate level
Service to intermediate head cisterns
Domestic cold water distribution systems
Head cisterns on intermediate floor with storage capacity for 4 hours when water used at average rate
Intermediate level
Break cistern divided for cleaning with each section containing a low level switch to stop pumping
Pumped service to other buildings
Basement level
Mains supply
Duty and standby pumps with isolation and N.R. valves
Quick acting N.R. valve of non-concussive type

24 hour storage on roof with small intermediate head cisterns at lower floors

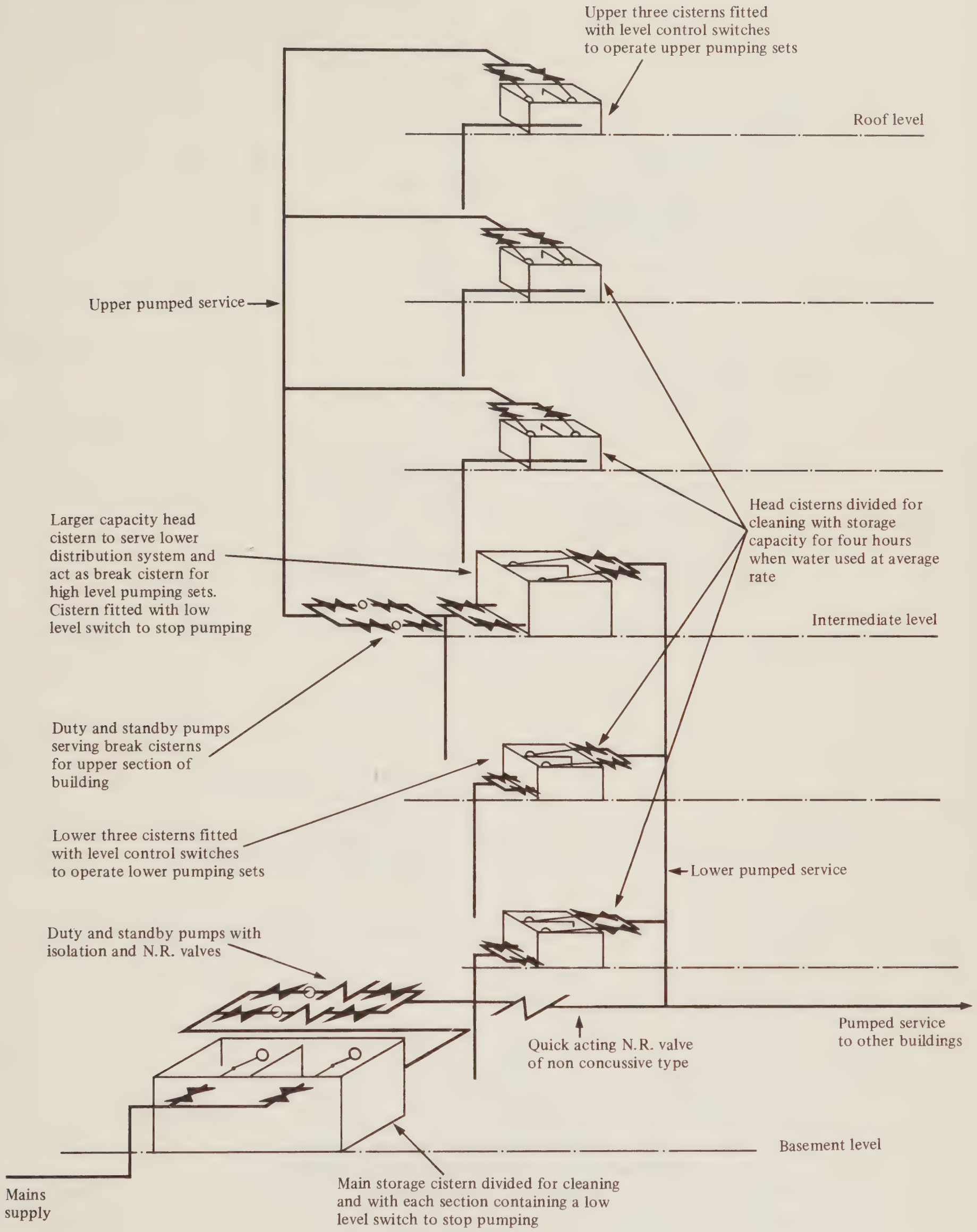
Appendix 3 (continued)


Roof & head cisterns all fitted with level switches to control pumping
Roof level
Pumped service riser
Domestic cold water distribution systems
Intermediate level
Domestic cold water distribution systems
Main storage roof and head cisterns on intermediate floors, with storage capacity for 24 hours in each for section of distribution system served
Intermediate level
Break cistern divided for cleaning with each section containing a low level switch to stop pumping
Pumped service to other buildings
Basement level
Mains supply
Duty and standby pumps with isolation & N.R. valves
Quick acting N.R. valve of non concussive type

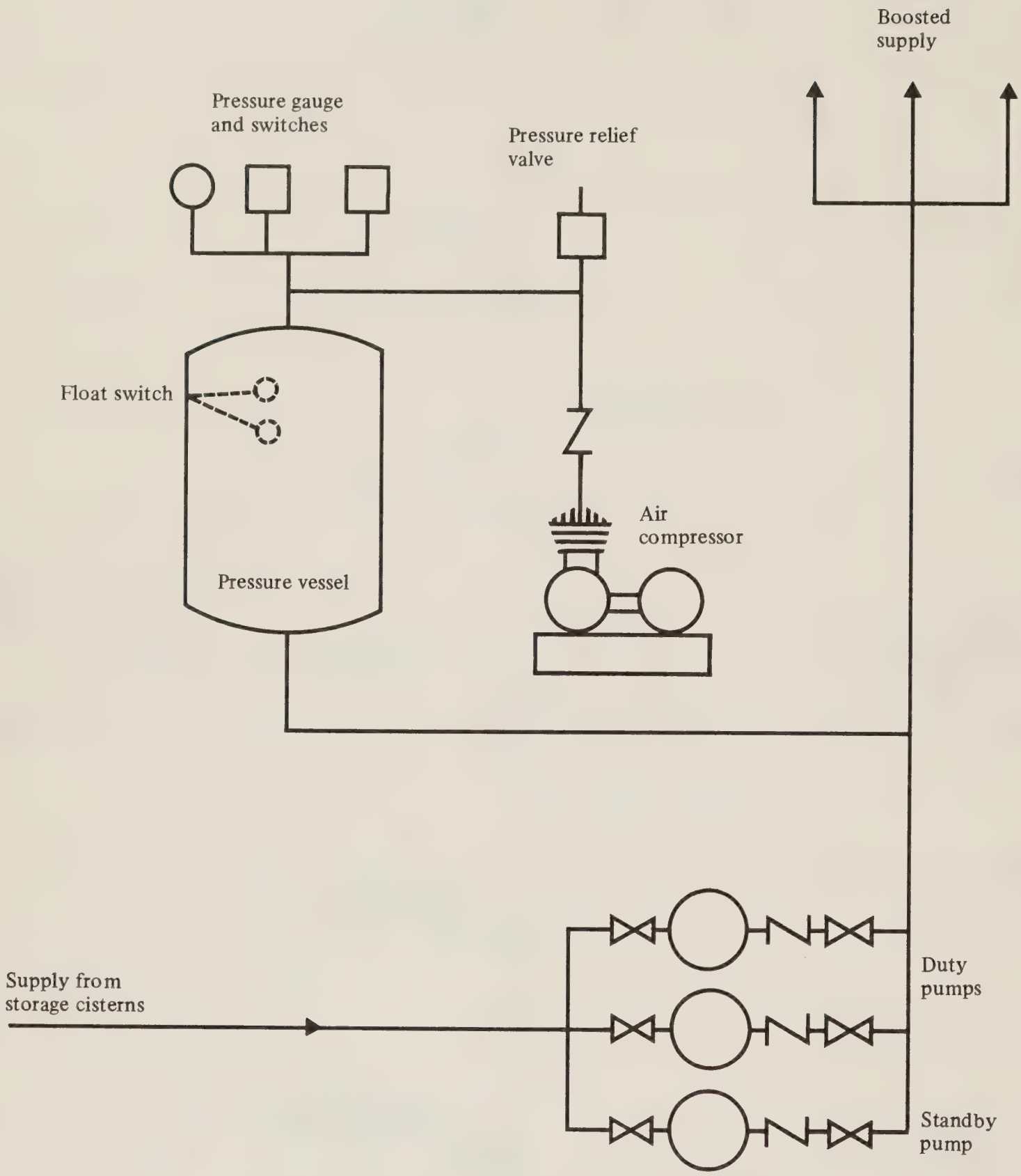
24 hours storage divided between cisterns at different levels where space is available on intermediate floors


Roof and head cisterns all fitted with level switches to control pumping
Roof level
Domestic cold water distribution systems
Pumped service riser
Intermediate level
Domestic cold water distribution systems
Roof and head cisterns on intermediate floors with storage capacity for 8 hours when water used at average rate
Intermediate level
Duty and standby pumps with isolation and N.R. valves
Pumped service to other buildings
Quick acting N.R. valve of non concussive type
Basement level
Mains supply
Main storage cistern divided for cleaning and with each section containing a low level switch to stop pumping

16 hour storage at basement level with 8 hour storage at roof and intermediate levels

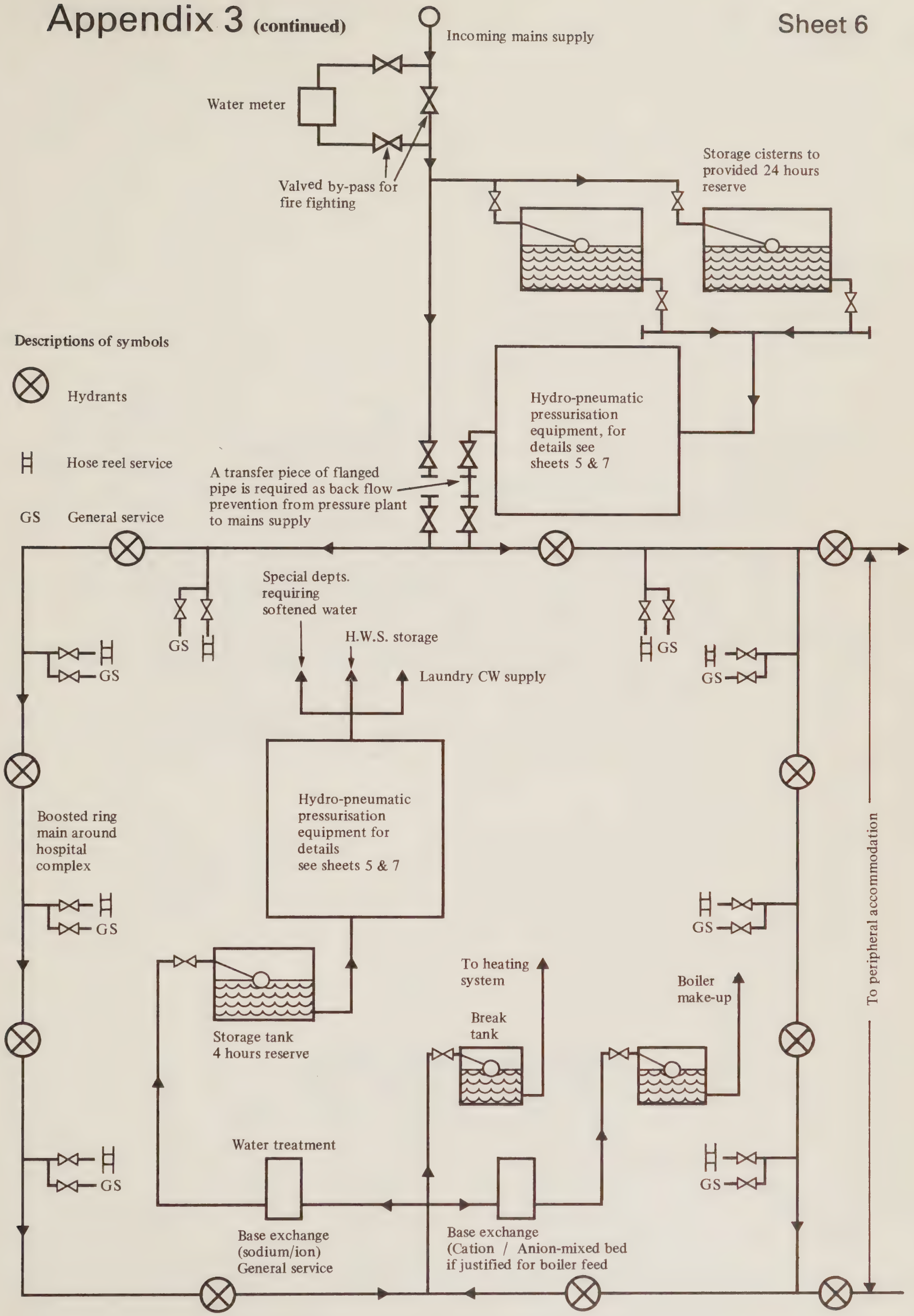

Upper three cisterns fitted with level control switches to operate upper pumping sets
Roof level
Upper pumped service
Larger capacity head cistern to serve lower distribution system and act as break cistern for high level pumping sets. Cistern fitted with low level switch to stop pumping
Head cisterns divided for cleaning with storage capacity for four hours when water used at average rate
Intermediate level
Duty and standby pumps serving break cisterns for upper section of building
Lower three cisterns fitted with level control switches to operate lower pumping sets
Lower pumped service
Duty and standby pumps with isolation and N.R. valves
Quick acting N.R. valve of non concussive type
Pumped service to other buildings
Basement level
Mains supply
Main storage cistern divided for cleaning and with each section containing a low level switch to stop pumping

24 hours storage divided between cisterns at different levels where space is available on intermediate floors

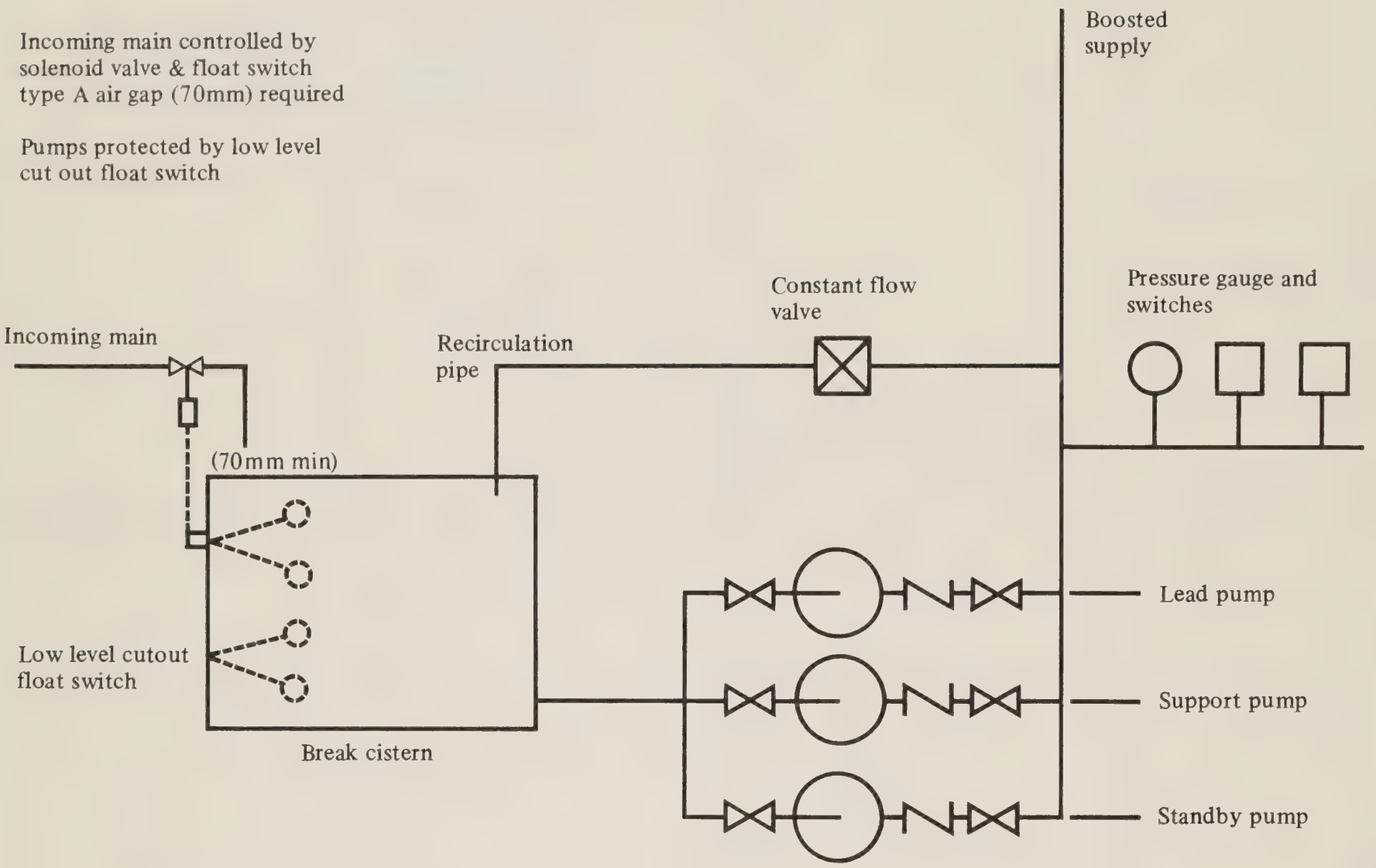


Hydro-pneumatic system with two duty pumps, one standby pump, pressure vessel and air compressor on automatic pressure control

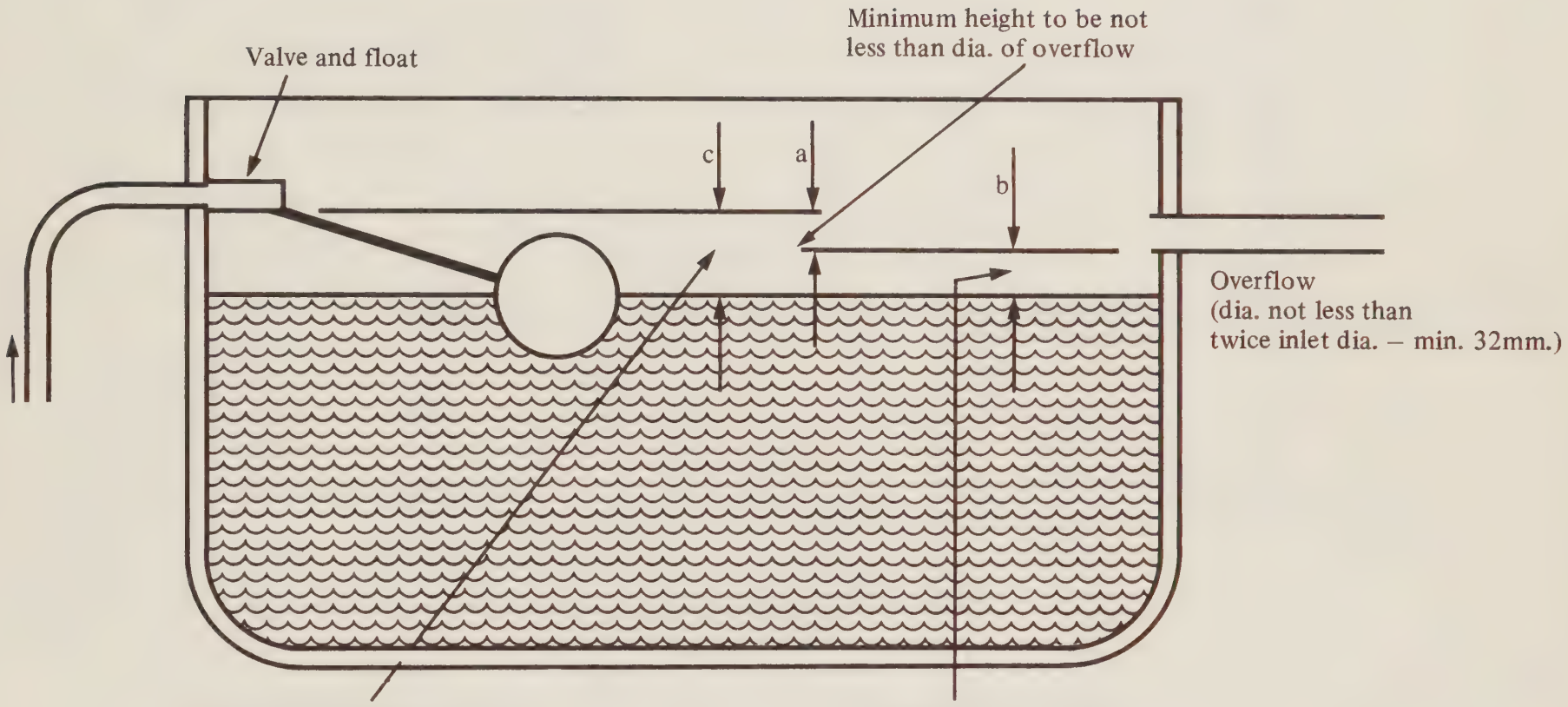
Appendix 3 (continued)


Incoming mains supply
Water meter
Valved by-pass for fire fighting
Storage cisterns to provided 24 hours reserve
Descriptions of symbols
Hydrants
Hose reel service
GS General service
Hydro-pneumatic pressurisation equipment, for details see sheets 5 & 7
A transfer piece of flanged pipe is required as back flow prevention from pressure plant to mains supply
Special depts. requiring softened water
H.W.S. storage
Laundry CW supply
GS
Boosted ring main around hospital complex
Hydro-pneumatic pressurisation equipment for details see sheets 5 & 7
To heating system
Break tank
Boiler make-up
Storage tank 4 hours reserve
Water treatment
Base exchange (sodium/ion) General service
Base exchange (Cation / Anion-mixed bed if justified for boiler feed
To peripheral accommodation

Typical distribution showing bulk water storage, pressurisation and water treatment arrangement


Incoming main controlled by solenoid valve & float switch type A air gap (70mm) required
Pumps protected by low level cut out float switch
Boosted supply
Constant flow valve
Pressure gauge and switches
Incoming main
Recirculation pipe
(70mm min)
Low level cutout float switch
Break cistern
Lead pump
Support pump
Standby pump

Continuous running load pumps with staged support pump and standby support pump



Minimum air gap between valve inlet and water level to be :-
up to 4546 litres cistern – 45mm
cisterns over 4546 litres – 75mm

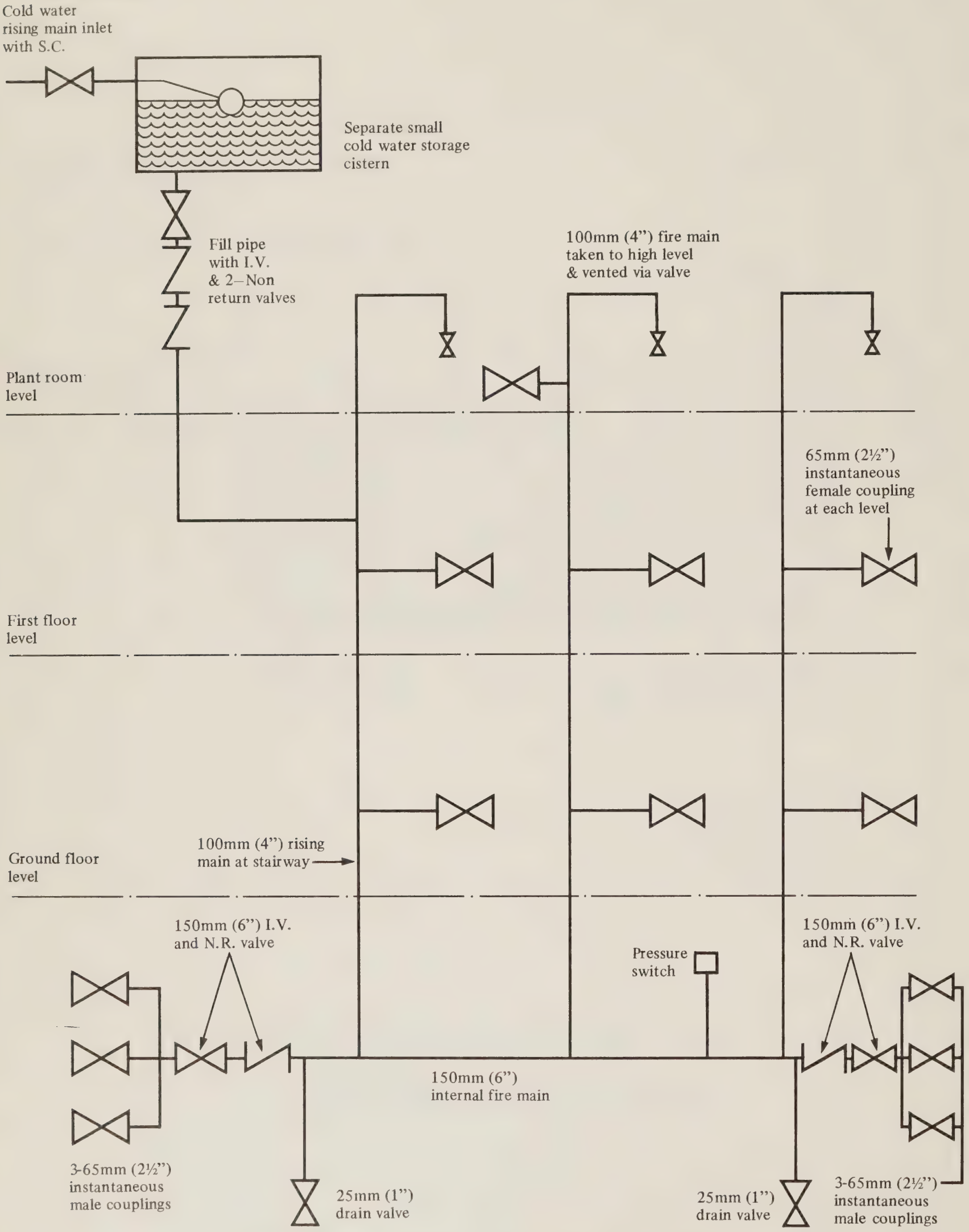
Highest level of water not less than 25mm below bottom of overflow

Note:
There may be additional requirements to ensure compliance with the Report of the Committee on backsiphonage in water installations.

Air gap requirements for ball valve controlled cistern

Appendix 3 (continued)

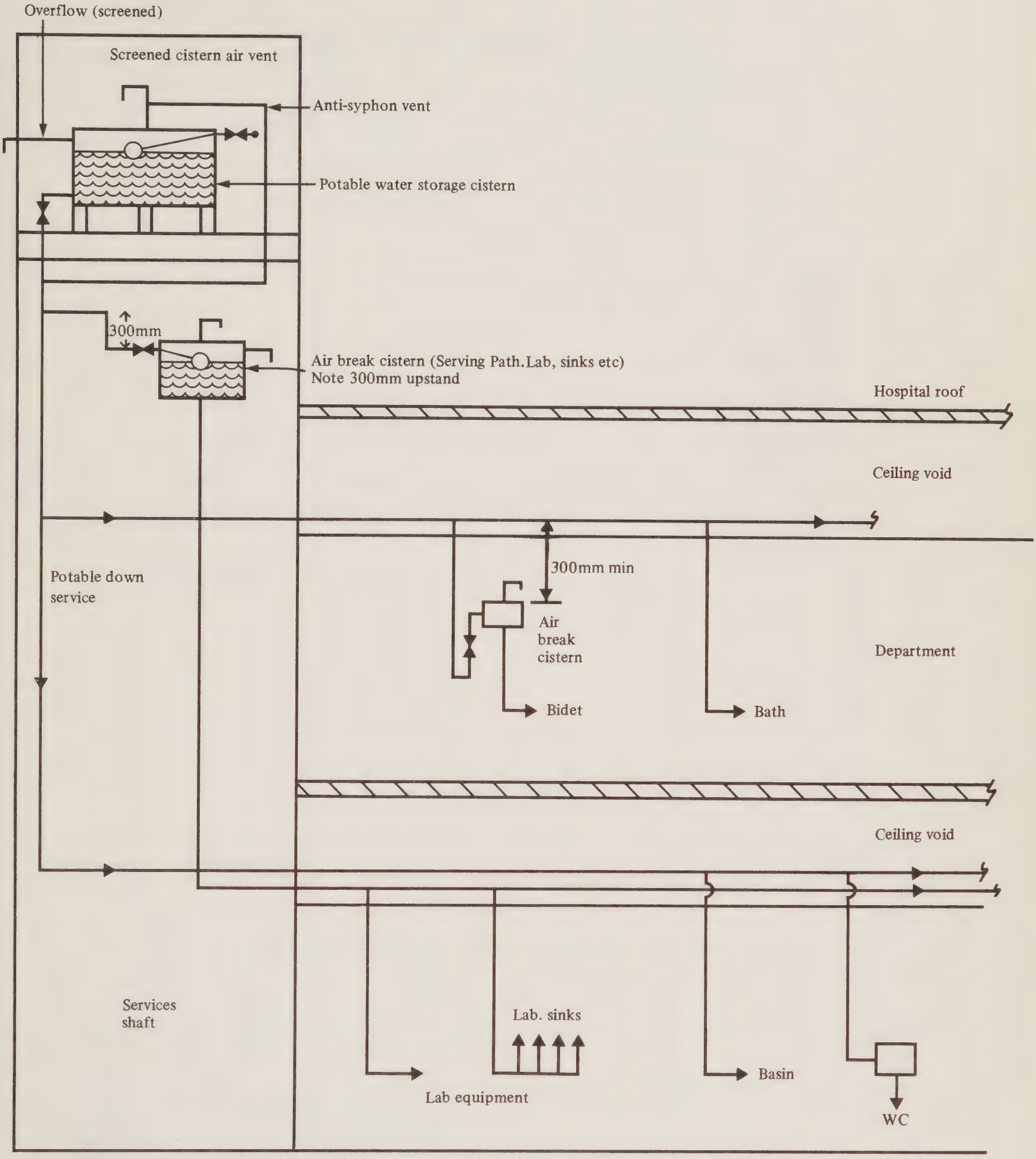
System building (Nucleus) hospitals water storage


Cold water rising main inlet with S.C.
Separate small cold water storage cistern
Fill pipe with I.V. & 2–Non return valves
100mm (4") fire main taken to high level & vented via valve
Plant room level
65mm (2½") instantaneous female coupling at each level
First floor level
Ground floor level
100mm (4") rising main at stairway
150mm (6") I.V. and N.R. valve
Pressure switch
150mm (6") I.V. and N.R. valve
150mm (6") internal fire main
3-65mm (2½") instantaneous male couplings
25mm (1") drain valve
25mm (1") drain valve
3-65mm (2½") instantaneous male couplings

Diagrammatic layout showing storage cistern for permanently charging indirectly connected internal fire mains

Appendix 3 (continued)

System building (Nucleus)
hospitals – Water storage

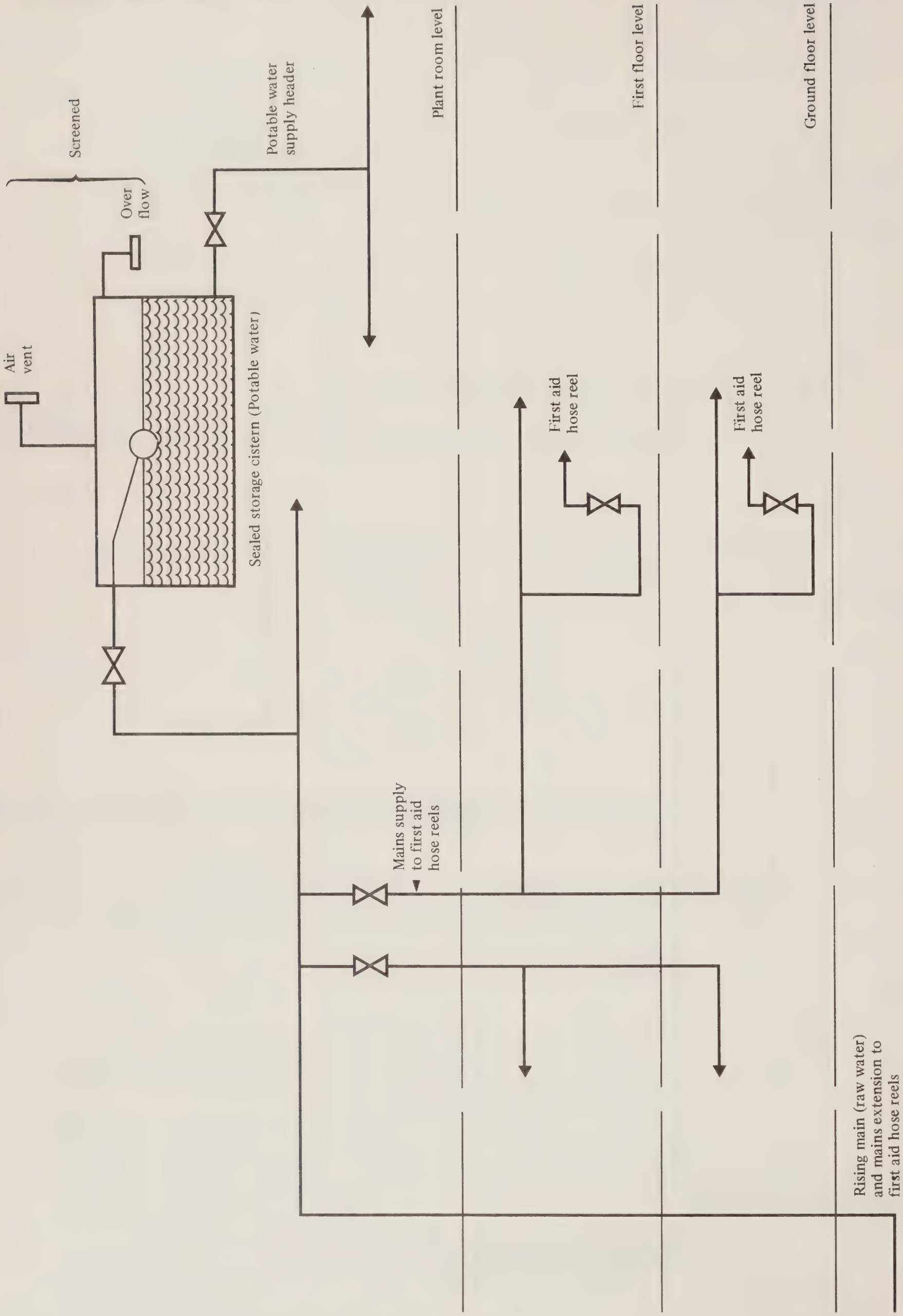


Note:- Services 'down fed' from ceiling

Cold water supply arrangement showing back-siphonage prevention to protect potable water supply from cistern

Appendix 3 (continued)

System building (Nucleus) hospitals – Water storage


Screened
Over flow
Air vent
Potable water supply header
Sealed storage cistern (Potable water)
Plant room level
First floor level
Ground floor level
First aid hose reel
First aid hose reel
Mains supply to first aid hose reels
Rising main (raw water) and mains extension to first aid hose reels

Potable water storage and fire main extension

Appendix 4

Department of Health and Social Security Standard Specifications and Documents on Water Supply.

Technical Preliminary Clauses	CS 1.1 to 1.59
Pipework	CS 13.1 to 13.101
Water Services	CS 15.1 to 15.51
Water Treatment Plant	CS 26.1 to 26.76
Fire Fighting Installation	CS 39.1 to 39.35

Appendix 5

Typical good specification for capillary jointing

1 Joints

All capillary fittings shall be to B.S. 864 with integral solder ring or of the end feed pattern. The procedure for making capillary joints shall be as follows:—

1.1 *Cleaning*

In order to promote solder flow and bonding, surfaces to be joined shall be cleaned free from dirt, oxide films, residual grease and oil. The sockets of all fittings (including the lip) and the tube end for a distance of up to 10 mm beyond the end of the fitting shall be thoroughly cleaned using fine (00) sand cloth, steel-wool or non-woven nylon pads impregnated with silicon carbide or aluminium oxide abrasives. Special wire brushes shall be used for the cleaning of sockets of 28 mm and smaller size. Where machines using wire brushes are used for cleaning tube ends and sockets etc these shall be approved by the Engineer before being used. Care shall be exercised to prevent particles of steel-wool, or the chosen cleaning material, entering the fitting or pipe. Any particles entering the fitting or pipe shall be removed. All surfaces, once cleaned, shall not be touched with bare hands or oily gloves since the deposition of skin oils, lubricating oils or grease impairs solder flow and wetting. Under no circumstances shall Emery cloth be used for cleaning purposes.

1.2 *Fluxing*

All flux shall be that recommended by the fitting manufacturer and where possible shall be cold water dispersible. Flux shall be thoroughly stirred as each tin is opened and at frequent intervals during use. Flux shall be applied sparingly yet adequately by means of a small brush or a clean cloth. All cloths shall be changed frequently and not be allowed to pick up dirt. Brushes shall be cleaned or changed frequently and not be allowed to pick up dirt. Flux shall *not* be applied using fingers. The cleaned surfaces shall be fluxed immediately, and if fluxing is not carried out within $1\frac{1}{2}$ hours of cleaning, then all joint surfaces shall be re-cleaned. Once fluxed, tube and fittings shall be immediately assembled.

All prepared joints shall be completed within a single work day. Fluxed and assembled joints remaining unsoldered at the end of the day shall be disassembled and wiped free of flux. They shall be re-cleaned, re-fluxed and re-assembled when work resumes.

Particular care shall be exercised to avoid leaving excessive flux inside or outside a completed joint. Only enough flux shall be applied to the cleaned surfaces to form a thin film over the areas to be joined. Fittings and tube ends shall *not* be dipped into the flux.

1.3 *Assembling*

The joint shall be assembled by inserting the tube into the fitting socket, ensuring that the tube is firmly up to the tube stop, then given a twist to help spread the flux over the two surfaces. Any excess flux shall be removed with a clean cloth before heat is applied.

1.4 *Heating*

Heat shall be applied by means of an approved type torch. Oxy-acetylene torches shall *not* be used for heating capillary fittings. The flame shall be played on the fitting and kept moving to heat the whole joint area and to prevent local overheating. Overheated joints and joints showing charred flux shall be rejected. In the case of integral solder ring fittings heating shall be continued until a complete ring of solder appears around the mouth of the socket. Heating shall then be stopped and the joint allowed to cool without disturbance. Additional solder *shall not* be applied and any joint found to have additional solder applied will be rejected. In the case of end feed fittings the joint shall be heated as stated above. When the joint is hot enough, approximately 3 mm dia solder wire or rod shall be applied to the mouth of the socket and should melt on contact with the tube and be drawn into the fitting by capillary action. Pre-tinning shall not be allowed and the length of solder wire or rod used shall not normally exceed the diameter of the tube being jointed.

1.5 *Testing*

Before any capillary joints are installed the mechanical sub-contractor shall arrange for one of his workmen, who is to carry out work under the contract, to prepare and make, at the bench, a tee joint typical of the size to be employed at the site. This joint shall be prepared and sectioned in the presence of the Engineer or his nominated representative. If accepted by the Engineer as a satisfactory joint, and being reasonably free from flux and foreign matter, the joint shall be labelled and retained by the Engineer for possible future reference.

Before any section of pipework employing capillary joints is pressure tested, the Engineer shall select a minimum of two fittings or 1% of the total number of fittings from each section and each service. These fittings shall be cut out and sectioned in the presence of the Engineer. The cut-out and sectioned fittings shall be examined by the Engineer or his nominated representative

for the excessive use of both flux and solder and to ensure that the tube has been cut square with the axis of the pipe and that all burrs have been removed. In the event of any joints not complying with *all* the relevant clauses of this specification or the standard of workmanship used in making the bench reference joint, then further joints shall be cut out for examination, up to a maximum of 10%. If, in the opinion of the Engineer, these reveal a level of workmanship which is unacceptable in comparison with the produced reference joint, then *all* joints shall be replaced at the expense of the sub-contractor. In the event of excessive flux usage being the only fault, then, at the sole discretion of the Engineer, the sub-contractor may be asked to arrange to have the installations cleaned of flux by an approved method, by an approved specialist contractor and at the sub-contractor's expense. In this latter case, joints shall again be removed, as previously specified, after the cleaning operation to prove the effectiveness of the cleaning process.

Costs for preparing and making the bench reference joint shall be carried by the mechanical sub-contractor. Costs associated with testing of production joints shall be covered by a provisional sum included for that purpose in the sub-contract.

Where this section is applied to contracts already let or on site, then only 2 joints per service per section shall be removed for examination by the direction of the Engineer.

Appendix 6

Sheet 1

Boundaries and Headquarters Offices of the Water and Health Authorities.

Rationalization of the Water Industry by the Water Act 1973 established 9 Regional Water Authorities for England and a Welsh National Water Development Authority for Wales.

Reorganization of the National Health Service also in 1973 formed 14 Regional Health Authorities in England and one Welsh Office.

Maps showing the boundaries and headquarter offices of the water and health authorities are shown and also a third map as a combination of the two to give an idea of the boundary relationships.

Appendix 6 (continued)

Regional Water Authorities Boundaries & H.Q. Offices

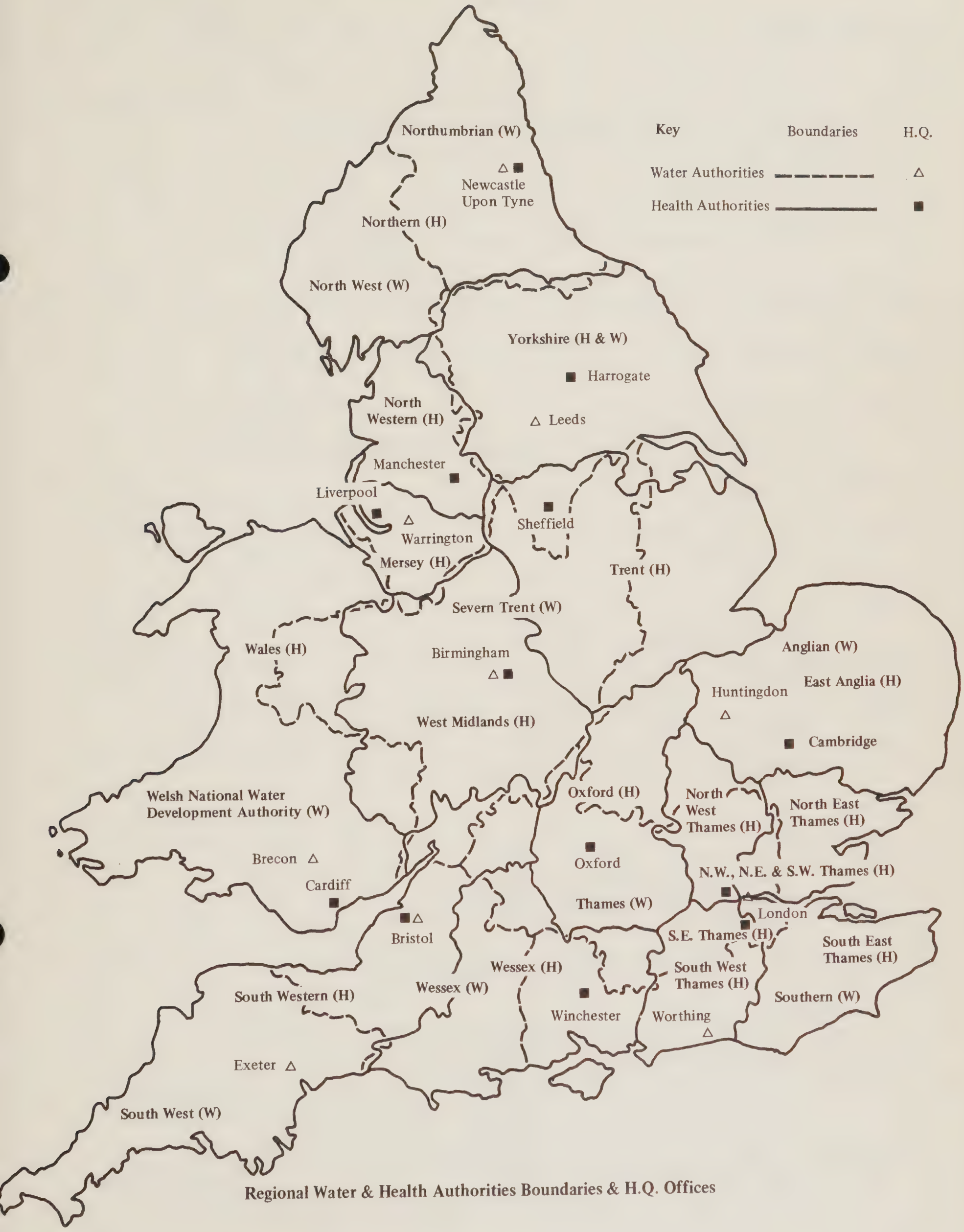
Appendix 6 (continued)

Sheet 3

Regional Health Authorities Boundaries & H.Q. Offices

Appendix 6 (continued)

Sheet 4



Regional Water & Health Authorities Boundaries & H.Q. Offices

Appendix 7

REFERENCES

(a) British Standards

Pipes and pipe fittings

Asbestos-cement pipes B.S.486

Pipes with plain ends and loose collars for rubber sealed compression joints.
Nominal bore 50 mm to 900 mm
Class 15 Test pressure 15 bar
Class 20 Test pressure 20 bar
Class 25 Test pressure 25 bar
The working pressure should not exceed half of the test pressure.

Capillary and compression tube fittings of copper and copper alloy B.S.864

Part 1 Nominal sizes $\frac{1}{8}$ in to $2\frac{1}{2}$ in inclusive.

Capillary and compression fittings for use with copper tubes complying with B.S.2871

Part 2 Nominal sizes 6 mm to 54 mm inclusive

Compression fittings for polyethylene pipes

Part 3 Nominal size 9·5 mm to 50·8 mm
Fittings for use with polyethylene pipes complying with requirements of B.S.1972, B.S.1973 and B.S.3796 for cold water services.
Maximum working pressures 12 bar at 20°C.

Cast iron flanged pipes and flanged fittings B.S.2035

Nominal bore 2 in to 48 in

Pipes

Class A	Test pressures: at foundry	8·97 bar
	Maximum after laying	5·98 bar
Class B	Test pressures: at foundry	14·95 bar
	Maximum after laying	11·96 bar
Class C	Test pressures: at foundry	20·92 bar
	Maximum after laying	17·93 bar
Class D	Test pressures: at foundry	26·90 bar
	Maximum after laying	23·91 bar

Fittings

Nominal bore 2 in to 48 in

Class A & B	Test pressures: at foundry	14·95 bar
	Maximum after laying	11·96 bar
Class C & D	Test pressures: at foundry	26·90 bar
	Maximum after laying	23·91 bar

Cast iron spigot and socket pipes (vertically cast) and spigot and socket fittings B.S.78

Part 1 ***Pipes***

Nominal bore 3 in to 48 in

Class A	Test pressures: at foundry	8·97 bar
	Maximum after laying	5·98 bar
Class B	Test pressures: at foundry	14·95 bar
	Maximum after laying	11·96 bar
Class C	Test pressures: at foundry	20·92 bar
	Maximum after laying	17·93 bar
Class D	Test pressures: at foundry	26·90 bar
	Maximum after laying	23·91 bar

Working pressures not specified

Appendix 7 (continued)

Part 2 ***Fittings***

Nominal bore 3 in to 48 in

Class A & B Test pressures: at foundry 14·95 bar
Maximum after laying 11·96 bar

Class C & D Test pressures: at foundry 26·90 bar
Maximum after laying 23·91 bar

Working pressures not specified

Cast iron pipe fittings for sprinklers and other fire installations B.S.1641

Nominal bore $\frac{1}{2}$ in to 6 in

Taper threads to B.S.21: Part 1

Working pressures up to 13·8 bar

Centrifugally cast (spun) iron pressure pipes for water, gas and sewerage B.S.1211

Nominal bore 3 in to 27 in

Class B Field test pressures 11·96 bar

Class C Field test pressures 17·93 bar

Class D Field test pressures 23·91 bar

Working pressures not specified

Fittings should comply with B.S.78

Copper alloy pipe fittings B.S.66 & 99

Nominal bore $\frac{1}{8}$ in (3·2 mm) to 4 in (100 mm)

For use with heavy gauge copper piping screwed in accordance with Table 1 B.S.61 Part 2

Internal hydraulic pressure 20·7 bar

Internal air pressure 5·2 bar

Malleable cast iron and cast copper alloy screwed pipe fittings for steam, air, water, gas and oil B.S.143 & 1256

Nominal bore $\frac{1}{16}$ in (1·6 mm) to 6 in (150 mm)

Working pressures up to 13·7 bar for water

B.S.143 having B.S.21 male and female taper thread

B.S.1256 having B.S.21 male threads taper
female threads parallel

Copper tubes for water, gas and sanitation B.S.2871

Part 1 Table X Sizes for half hard and light gauge copper tube
6 mm to 159 mm
Maximum working pressures 133 bar to 15 bar respectively

Table Y Sizes for half hard and annealed copper tube
6 mm to 108 mm
Maximum working pressures 144 bar to 22 bar respectively

Table Z Sizes for hard drawn, thin wall copper tube
6 mm to 159 mm
Maximum working pressures 133 bar to 15 bar respectively

Pipe threads where pressure-tight joints are not made on the threads B.S.2779

Nominal bore $\frac{1}{16}$ in (1·6 mm) to 6 in (150 mm)

Close, medium, free and normal class tolerances

Flanges and bolting for pipes, valves and fittings B.S.4504

Part 1 Ferrous

Pressure/temperature ratings in range of 2·5 to 400 bar

Appendix 7 (continued)

Part 2 Copper alloy and composite flanges
Nominal sizes up to 1800 mm
Nominal pressures 6 to 40 bar

Lead pipes and lead alloy pipes for other than chemical purposes — B.S.602 & 1085
Nominal bore 10 mm to 50 mm
Table 1 Service and distributory pipes underground
Working pressures up to 4·5, 7·5 and 10·5 bar
Table 2 Service pipes above ground (cold water)
Working pressures up to 2·25 and 4·5 bar

Joints and fittings for use with unplasticized PVC pressure pipes — B.S.4346
Part 1 Injection moulded unplasticized PVC fittings for solvent welding for use with pressure pipes including potable water supply.
Nominal size 9·5 mm to 305 mm
Part 2 Mechanical joints and fittings principally of unplasticized PVC
Part 3 Solvent cements

Pipe threads for tubes and fittings where pressure-tight joints are made on the threads — B.S.21
Nominal bore $\frac{1}{16}$ in (1·6 mm) to 6 in (150 mm)
Part 1 Jointing threads
Part 2 Longscrew threads

Polythene pipe (type 32) for cold water services — B.S.1972
Nominal size 9·5 mm to 101·6 mm
Maximum working pressures Class B 5·98 bar
Class C 8·96 bar
Class D 11·93 bar
Temperature of 20°C

Polythene pipe (type 50) for cold water services — B.S.3284
Nominal size 9·5 mm to 152·4 mm
Maximum working pressures Class B 5·98 bar
Class C 8·96 bar
Class D 11·93 bar

Threads for light gauge copper tubes and fittings — B.S.61
Part 2 Nominal bore $\frac{1}{8}$ in (3·2 mm) to 4 in (100 mm)
Tables 1 & 2 Screw Threads for copper pipes

Butt-welding pipe fittings for pressure purposes — B.S.1965
Part 1 Carbon steel
Nominal bore 1 in (25·4 mm) to 16 in (406·4 mm)
Part 2 Austenitic stainless steel
Nominal bore 1 in (25·4 mm) to 16 in (406·4 mm)

Steel pipes, fittings and specials for water, gas and sewage—seamless — B.S.534
Outside diameter $2\frac{3}{8}$ in (60·3 mm) to 84 in (2134 mm)
Test pressures 44·82 bar to 68·95 bar

Steel tubes and tubulars suitable for screwing to B.S.21 pipe threads — B.S.1387
Nominal bore $\frac{1}{8}$ in (3·2 mm) to 6 in (150 mm) in medium and heavy thicknesses and up to 4 in (100 mm) in light thickness
Hydraulic test pressure 48·26 bar

Appendix 7 **(continued)**

Light gauge stainless steel tubes B.S.4127

Part 2 Nominal size 6 mm to 42 mm
Hydraulic test at gauge pressure 35 bar min
Pneumatic test at gauge pressure 4 bar min

Water well casing B.S.879

Screwed and socketed 4 in (100 mm) to 24 in (610 mm)
Screwed flush butt joint 4 in (100 mm) to 24 in (610 mm)
Butt welded joint 4 in (100 mm) to 48 in (1219 mm)

Unplasticized PVC pipe for cold water services B.S.3505

Nominal size 9·5 mm to 152·4 mm
Maximum working pressure class B 6 bar
C 9 bar
D 12 bar
E 15 bar

Wrought steel pipe fittings (screwed BSP thread) B.S.1740

Part 1 ***Metric units***
Nominal size 6 mm to 150 mm
Hydraulic test pressure 50 bar
Internal air pressure test 7 bar

Part 2 ***Imperial units***
Nominal size $\frac{1}{8}$ in to 6 in

Cisterns, tanks and cylinders

Asbestos-cement cisterns B.S.2777

12 sizes 17 litre to 701 litre capacity

Cast iron sectional tanks (rectangular) B.S.1563

Bolted sectional tanks up to 40 ft sq and 12 ft deep made from unit plates 2 ft, 3 ft and 4 ft sq

Pressed steel sectional tanks (rectangular) B.S.1564

Sizes 52 ft sq and 16 ft deep made from unit plates of 4 ft sq

Polyolefin or olefin copolymer moulded cold water storage cisterns B.S.4213

This British Standard specifies requirements for cisterns manufactured for domestic or industrial use.

Galvanized mild steel cisterns, covers, tanks and cylinders B.S.417

Part 1 ***Imperial units***
Cisterns 20 sizes from 4 to 740 gallons capacity in two grades
Tanks 5 sizes from 21 to 34 gallons capacity in two grades
Cylinders 10 sizes from 16 to 97 gallons capacity in three grades

Part 2 ***Metric units***
Cisterns 2 grades 20 sizes from 18 to 3364 litre capacity
Tanks 2 grades 5 sizes from 95 to 155 litre
Grade A working head 4·5 metres
Grade B working head 3 metres
Cylinder 3 grades 10 sizes 73 to 446 litre capacity
Grade A working head 30 metres
Grade B working head 18 metres
Grade C working head 9 metres

Appendix 7 (continued)

Horizontal mild steel welded storage tanks — B.S.2594

The sizes of tanks range from 3 ft 6 in in diameter by 4 ft nominal length up to 9 ft diameter by 30 ft nominal length

Taps and valves — B.S.1212

Part 1 Ball valves (piston type) sizes $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$ and 2 in

Part 2 Ball valves (diaphragm type). Two sizes $\frac{3}{8}$ and $\frac{1}{2}$ in having four seat sizes ($\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$ and $\frac{3}{8}$ in bore)

Test pressure 20 bar

Working pressure		
	High	14 bar
	Medium	7 bar
	Low	3 bar

Floats for ball valves (copper) — B.S.1968

Class A soldered joints

B solderless joints

C brazed welded or silver soldered joints

Floats for ball valves (plastic) for hot and hold water — B.S.2456

Nominal sizes 4, $4\frac{1}{2}$, 5 and 6 in as specified in B.S.1212 Parts 1 and 2
max. temperature 90°C

Cast iron wedge and double disc gate valves for general purposes — B.S.5150

Sizes DN 10 to 1000
PN 1·6, 2·5, 4, 6, 10, 16 and 25

Cast iron gate (parallel slides) valves for general purposes — B.S.5151

Sizes DN 40 to 1000
PN 10, 16 and 25

Cast iron globe and globe stop and check valves for general purposes — B.S.5152

Sizes DN 10 to 450
PN 10, 16 and 25

Cast iron check valves for general purposes — B.S.5153

Sizes DN 10 to 800
PN 6, 10, 16 and 25

Copper alloy globe, globe stop and check, check and gate valves for general purposes — B.S.5154

Sizes DN 10 to 80
PN 16, 25 and 40 flanged ends
PN 16, 25, 32 and 40 screwed ends

Cast iron butterfly valves for general purposes — B.S.5155

Sizes DN 40 to 2000
PN 2, 5, 6, 10, 16 and 25

Steel gate (parallel slide) valves for general purposes — B.S.5157

Sizes DN 40 to 600
PN 16, 25, 40, 64 and 100

Double flanged C.I. wedge gate valves for waterworks purposes — B.S.5163

Sizes DN 10 to 300
PN 6, 10 and 16

Draw-off taps and stop valves for water services (screwdown pattern)	B.S.1010
Part 1 Imperial units Nominal sizes $\frac{1}{4}$ in to 2 in *Draw-off taps and above ground stop valves*	
Part 2 Nominal bore 6·4 mm to 5 mm Test pressures not less than 20 bar internal hydraulic Test pressures not less than 5 bar internal pneumatic while tap is completely immersed in water	
Underground fire hydrants and dimensions of surface box openings	B.S.750
Guards for underground stop valves	B.S.1185
Identification of pipelines	B.S.1710
Materials for water tap and stop valve seat washers	B.S.3457
Rubber joint rings for gas, water mains and drainage purposes	B.S.2494
Thermal insulating materials	B.S.1334
Surface boxes for gas and waterworks purposes	B.S.1426 & 3461
Treatment of water for land boilers	B.S.2486

(b) British Standard Codes of Practice

C.P.99 Frost Precautions for Water Sanitary Services in Buildings
C.P.310 Water Supply
C.P.402.101 Hydrant Systems
C.P.2007 Design and Construction of Reinforced and Prestressed Concrete Structures for Storage of Water and other Aqueous Liquids

(c) Her Majesty's Stationery Office Publications

Model Water Byelaws (1966 Edition)
The Bacteriological Examination of Water Supplies
Report of the Committee on Backsiphonage in Water Installations
Hospital Technical Memorandum No 13—Planned Preventive Maintenance—A system for Engineering Plant and Services now superseded by Estmancode
Hospital Technical Memorandum No 16—Fire Precautions
Hospital Technical Memorandum No 17—Commissioning of Hospital Engineering Services
Hospital Technical Memorandum No 23—Access and Accommodation for Engineering Services

(d) Institution of Electrical Engineers

Regulations for the Electrical Equipment of Buildings

(e) Chartered Institution of Building Services

Guide Book B, 1970 (originally published by the Institution of Heating and Ventilating Engineers)

Appendix 8

NAMES AND ADDRESSES OF BODIES AND AUTHORITIES REFERRED TO IN THE TEXT

North West Water Authority
Dawson House
Great Sankey
WARRINGTON
Lancs
WA5 3LW
Tel: Penketh (092 572) 4321

South West Water Authority
3–5 Barnfield Road
EXETER
EX1 1RE
Tel: Exeter (0392) 50861

Yorkshire Water Authority
West Riding House
67 Albion Street
LEEDS
LS1 5AA
Tel: Leeds (0532) 448201

Severn Trent Water Authority
Abelson House
2297 Coventry Road
Sheldon
BIRMINGHAM
B26 3PS
Tel: Birmingham (021 743) 4222

Welsh National Water Development Authority
Cambrian Way
BRECON
Powys
LD3 7HP
Tel: Brecon (0874) 3181

Anglian Water Authority
Diploma House
Grammar School Walk
HUNTINGDON
PE18 6NZ
Tel: Huntingdon (0480) 56181

Wessex Water Authority
Techno House
Redcliffe Way
BRISTOL
BS1 6NY
Tel: Bristol (0272) 25491

Northumbrian Water Authority
Northumbria House
Regent Centre
Gosforth
NEWCASTLE UPON TYNE
NE3 3PX
Tel: Gosforth (0632) 843151

Southern Water Authority
Guildbourne House
WORTHING
Sussex
BN11 1LD
Tel: Worthing (0903) 205252

Thames Water Authority
New River Head
Rosebery Avenue
LONDON
EC1R 4TP
Tel: 01 278 2300

Institute of Geological Sciences
Exhibition Road
LONDON
SW7 2DE
Tel: 01 589 3444

National Water Council
1 Queen Anne's Gate
LONDON
SW1

Institute of Plumbing
Scottish Mutual House
29 North Street
HORNCHURCH
RM11 1RU

Water Research Centre
PO Box 16
Henley Road
Medmenham
MARLOW
Bucks
SL7 2HD
Tel: Hambleden (049 166) 531

Fire Officers Committee
Fire Protection Association
Aldermary House
10/15 Queen Street
LONDON
EC4N 1TJ
Tel: 01 248 5222

Department of Health, Education, and Welfare
Washington, D.C.

Health Technical Memorandum

Department of Health and Social Security
Welsh Office

Prices do not include postage.
Binders for this series of Notes are available price £1.80
Department of Health and Social Security, Welsh Office and Health Building guidance publications include: Health Building Notes, Design Notes, Equipment Notes, Building Bulletins and Technical Memoranda.

Government publications can be purchased from the Government Bookshops in London (post orders to PO Box 569, SE1), Edinburgh, Cardiff, Belfast, Manchester, Birmingham and Bristol or through booksellers.

Health Technical Memoranda

1	Anti-static precautions: rubber, plastics and fabrics	50p
2	Anti-static precautions: flooring in anaesthetising areas	50p
6	Protection of condensate systems: filming amines	12p
7	Electrical services: supply and distribution	£3
8	Safety code for electro-medical apparatus	95p
9	Pneumatic tube communication systems	35p
10	Pressure steam sterilizers*	
11	Emergency electrical services	40p
14	Abatement of electrical interference*	
15	Patient/Nurse call systems	£1.50
16	Fire precautions*	
17	Commissioning of hospital engineering services*	
19	Facsimile telegraphy: the transmission of pathology reports within a hospital	85p
20	Staff location systems*	
22	Piped medical gases, medical compressed air and medical vacuum installations	£4.50
22	Supplement "Permit-to-Work" System	£1
23	Access and accommodation for engineering services	41p
26	Commissioning of oil, gas and dual fuel fired boilers	60p
27	Cold water supply storage and mains distribution	£5

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